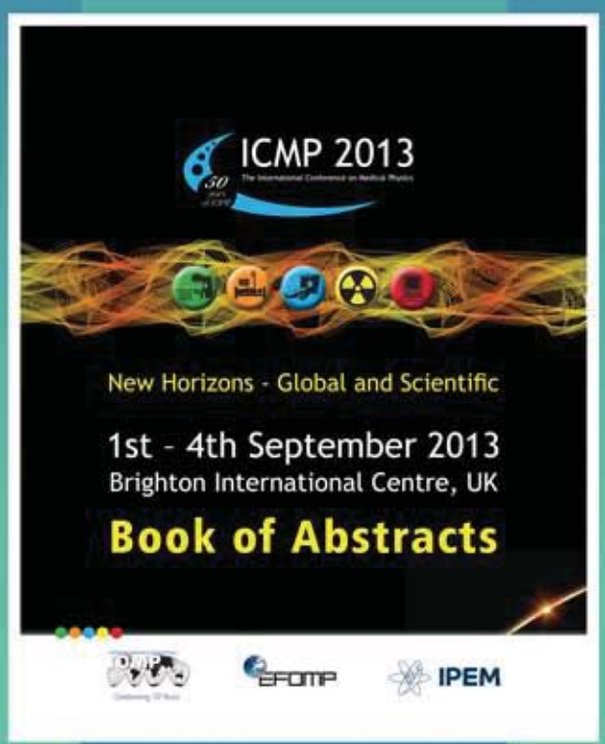
MEDICAL PHYSICS
International



IOMP

A Journal of the International Organization for Medical Physics

Volume 1, Number 2, August 2013

MPI

International Day of Medical Physics

November 7, 2013

Radiation Exposure from Medical Procedures: Ask the Medical Physicist!

International Organization for Medical Physics

IOMP

MEDICAL PHYSICS INTERNATIONAL

A JOURNAL OF

THE INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS

Volume 1, Number 2, March 2013

MEDICAL PHYSICS INTERNATIONAL

A Journal of the International Organization for Medical Physics

Aims and Coverage:
Medical Physics International (MPI) is the official IOMP journal. The journal provides a new platform for medical physicists to share their experience, ideas and new information generated from their work of scientific, educational and professional nature. The e- journal is available free of charge to IOMP members.

MPI web address: www.mpijournal.org

Published by: The International Organization for Medical Physics (IOMP), web address: www.iomp.org ; post address: IOMP c/o IPEM, 230 Tadcaster Road, York YO24 1ES, UK.

ISSN 2306 - 4609

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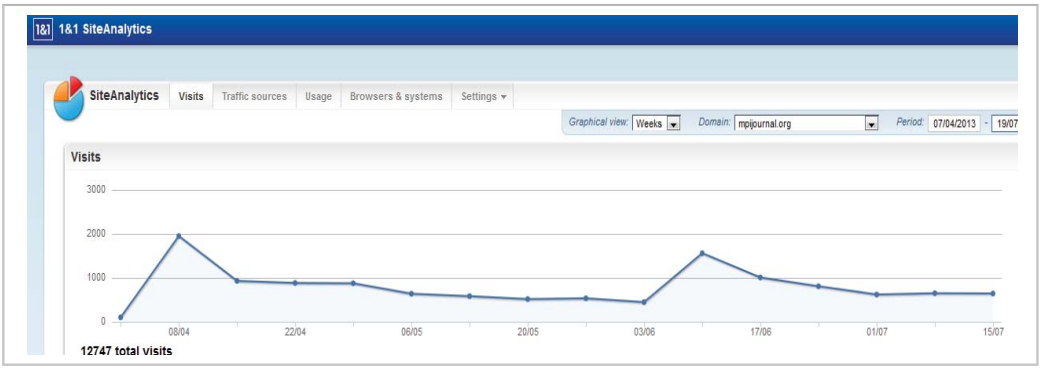


EDITORIAL 1

The instant success of the new IOMP Journal Medical Physics International showed the need of such forum for our colleagues. The web statistics of www.mpijournal.org shows that for the first three months of the life of the Journal (2/04/2013 – 19/07/2013) the journal web site had 12,474 visitors.

Papers from all sections of the MPI Journal have been downloaded hundreds of times, what shows that the construction and coverage of the Journal have been well chosen by the Editorial team. The Journal will continue to support these sections and invites authors to consider submitting papers for the 3rd MPI issue (planned for March 2014, with submission deadline 31 January 2014).

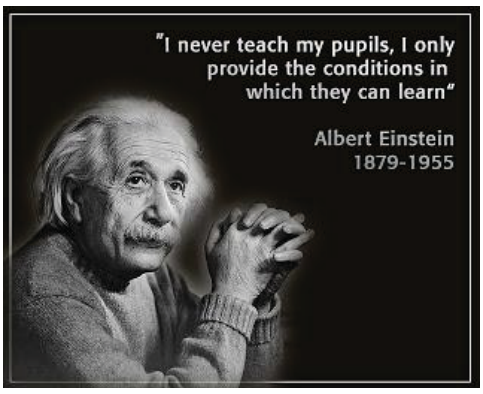
Physicians and other medical professionals who use these advanced technologies need an understanding of the physics

This second issue of MPI celebrates the 50th anniversary of the IOMP and we have initiated a series of papers describing the history of the Organisation, its growth and the rapid expansion of medical physics in the last decades. Together with it we enter into a new phase – publishing proceedings from International Conferences on Medical Physics, starting with the abstracts of the International Conference of Medical Physics – ICMP2013, Brighton, UK.

The conference in Brighton (1-4 September 2013) is the 20th International Conference on Medical Physics and is co-organised by the UK Institute for Physics and Engineering in Medicine (IPEM), the European Federation of Organisations for Medical Physics (EFOMP) and the International Organisation for Medical Physics (IOMP).

Slavik Tabakov, Co-Editor, King's College London, UK

EDITORIAL 2



With the rapid advances in both medical imaging and radiation therapy technology and applications around the world, the role of the medical physicist as an educator is expanding and becoming much more significant, but also with some challenges.

principles in order to make intelligent decisions that will contribute to effective and safe use. Medical physicists have the opportunity to provide this education. The challenge is that the physics knowledge needed by physicians for effective clinical applications is often different from what we as medical physicists learned in our academic studies. The common practice of "teaching" what "we were taught" is generally not appropriate. Let's consider the guidance provided by Albert Einstein shown here.

What does that mean for us as clinical medical physicists and medical physics educators? Especially for our students who are physicians and other clinical professionals we need to develop conditions and learning activities in which they integrate physics directly into the clinical practice. This is achieved through a close collaboration between physicists and physicians where knowledge is shared in both directions.

One of the goals of this journal is to publish articles that can contribute to more clinically- focused physics education and provide resources, and links to web-based resources, for medical physicists to use.

Perry Sprawls, Co-Editor, Atlanta, USA

HISTORY AND HERITAGE

A HISTORY OF THE INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS – 50 YEARS ANNIVERSARY – PART I

Azam Niroomand-Rad[1], Colin Orton[2], Peter Smith[3], and Slavik Tabakov[4]

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[3]Aberdeen, UK, [4]Kings College, London, UK

Abstract—In celebration of 50 years Golden Anniversary of the founding of the International Organization for Medical Physics (IOMP), Part I of this article is written to describe early development of events and discussions that led to the formation of the Organization in 1963, followed by early years expansion of the Organization. A summary of the major achievements over the last 50 years is included.

Keywords— IOMP, IUPESM, ICSU, ILO, IUPAP.

I. Introduction

This article is written by past and present members of the International Organization for Medical Physics (IOMP) History subcommittee in recognition of the Golden Anniversary of the founding of the Organization in 1963. Starting with just four National Members representing a few hundred medical physicists, the organization has grown to over 80 National Member Organizations, six Regional Organizations, and over 18,000 individual members. This article highlights the major activities and accomplishments of the IOMP and recognizes the enormous time and effort donated by many of its voluntary members to promote the purposes and objectives of the Organization.

II. IOMP early history

In the early 1950s medical physicists, especially members of the only national society of medical physicists at the time, the Hospital Physicists' Association (HPA) in the UK, began to be interested in meeting colleagues from other countries to exchange ideas and promote medical physics but their only opportunities to meet had been at the International Congresses of Radiology in 1950 (in London) and 1953 (in Copenhagen). There were sessions on radiological physics at these congresses but relative few medical physicists attended. What were needed were international conferences that would attract far more medical physicists, maybe organized by an international organization of medical physicists.

The first concrete proposal to form such an international association of medical physicists was made by Norman Veale (Guy's Hospital, London, UK) at an HPA meeting in October 1954. This proposal was discussed at a meeting of Swedish medical physicists in December 1955 and, in September 1956, a written proposal to this effect was sent by Walter Moos (University of Illinois, Chicago, USA) to medical physicists in several countries.

Subsequently, in September 1957, HPA President Ray Wood wrote to Walter Moos, Sven Brenner (Sweden), Edith Quimby (USA), and Harold Johns (Canada) to propose a preliminary meeting to discuss the issue. Following this, in April 1958, HPA physicists met in Erlangen, Germany with Sven Brenner and Felix Wachsmann (Germany). They agreed that the HPA should be the organizing body for an international organization and called for another meeting the following year. Having been informed of this, medical physicists in the USA, John Laughlin, Gail Adams and Bob Loevinger, met informally in May 1958 to discuss this topic and agreed that an international organization was desirable and that it should be formed of medical physics national societies and not individuals. Then, in July 1959, the HPA held a special one-day meeting at the end of the IXth International Congress of Radiology in Munich. Over 80 people attended from 20 countries. The Chairman was Jack Boag (UK) and the Secretary Roy Ellis (UK). There were presentations by 26 speakers from 12 countries. Comments included:

- there was a need for an international organization so as to secure recognition by the International Council of Scientific Unions (ICSU)
- that more personal contact between medical physicists in different countries was needed and that the International Congresses of Radiology did not meet the needs
- that an international body could be of great assistance to those countries that did not have a national society

- that, in the event an International Union of Biophysics were to be formed, medical physicists might be linked with this
- that the ultimate objective be the formation of an organization covering both pure and applied biophysics.

Jack Boag proposed a Motion, which was approved unanimously, to the effect that they agreed to the formation of an international body covering the field of both pure and applied biophysics, and that the HPA should form a committee called "The International Liaison Committee on Medical Physics" to correspond with all the national societies of medical physics represented at this meeting as well as those attendees from countries that had no such societies. There ensued considerable correspondence by John Mallard, HPA Honorary Secretary, to these national societies and to those from countries with no medical physics society encouraging them to form a national society.

In 1961, the HPA invited medical physicists to attend a meeting of the International Liaison Committee during the 2nd International Biophysics Congress in Stockholm. It was during this congress that the International Organization of Pure and Applied Biophysics (IOPAB) was formed. Over 50 medical physicists attended the meeting from 12 countries (Austria, Belgium, Czechoslovakia, Denmark, Germany, Holland, Hungary, Italy, Japan, Sweden, the UK and the USA). The Chairman was Len Lamerton (HPA President) and there was general consensus for the need to establish an International Organization for Medical Physics (IOMP), independently of whether or not it was to be affiliated with the newly-formed IOPAB, and that it should be formed as soon as possible. An International Steering Committee was formed to:

- draft a Constitution
- consider the problems of affiliation with the IOPAB
- consider holding a scientific conference within a reasonable time
- prepare a report within a year.

Sven Brenner (Sweden) was appointed Chairman, Len Lamerton (UK), Vice-Chairman, John Mallard (UK), Secretary, with members Monte Cohen (IAEA), Bo Lindell (Sweden), Bruno Schober (Czechoslovakia), and Rosalyn Yalow (USA), with an additional representative each from Canada, Germany, Holland, Hungary, and Japan to be appointed. *Physics in Medicine and Biology* (PMB) Editor Jo Rotblat suggested that, if the organization needed a journal, PMB might be suitable.

The International Steering Committee held its first meeting at the Xth International Congress of Radiology in Montreal in August 1962. It was agreed to form the IOMP, to be inaugurated on January 1st, 1963. The Steering Committee was to act as the provisional Council until elections could be held at the 1st International Conference. The Draft Statutes was approved as was a proviso that the IOMP should apply for affiliation to IOPAB as a step toward being associated with ICSU. News of the imminent inauguration of the IOMP, along with a copy of the Statutes, was to be sent to all the known representatives of as many countries as possible asking them to join. The four founding members were Canada, Sweden, the UK and the USA [1]. The Statutes set forth the three objectives and four powers of the IOMP:

Objectives:

- To organize international co-operation in medical physics and promote communication between various branches of medical physics and allied subjects.
- To contribute to the advancement of medical physics in all its aspects.
- To advise on the formation of National Committees for Medical Physics in those countries which lack such organization.

Powers:

- To set up bodies for special purposes
- To organize international meetings and conferences
- To collaborate or affiliate with other scientific organizations
- To develop any activity deemed helpful to the forwarding of its declared objects.

III. MEMBER COUNTRIES (1963-2013)

Countries are represented by National Organizations. Where more than one national organization wishes to join, the recognised national body is a national committee representing all members of such national medical physics organizations. Originally National Organizations were referred to as 'adhering national bodies' but in 2009 the Statutes were amended so that National Organizations were included as one the membership categories.

The Organization was established in 1963 with 4 founding countries. By 1998, within 25 years, this had grown to 37 Member Countries. Now, after 50 years, there are 84 Member Countries. In chronological order:
(1-4) Canada, Sweden, UK, USA, (5-9) Germany (West-East were united in 1991), Hungary, Israel, Poland, South Africa, (10-16) Brazil, Finland, France, Greece, Mexico, Netherlands, New Zealand, (17-18) Ireland, Norway, (19-21) Italy, Japan, Spain, (22-27) Austria, Belgium, Denmark, India, Switzerland, Thailand, (28-31) China, Columbia, Nigeria, Turkey (32-35) Australia, Hong Kong, Philippine, Sri Lanka, (36) Malaysia, (37) Cyprus, (38-43) Argentina, Bulgaria, Ghana, Korea, Romania, Tanzania (44-49)

Moldova, Pakistan, Russia, Slovenia, Sudan, Trinidad & Tobago, (50-55) Algeria, Indonesia, Iran, Panama, Venezuela, Zimbabwe, (56-62) Cuba, Estonia, Georgia, Lithuania, Morocco, Ukraine, Zambia, (63-64) Ecuador, Portugal, (65-71) Bangladesh, Chile, Egypt, Nepal, Taiwan, Singapore, Uganda, (72) Mongolia, (73-74) Jordan, Croatia, (75-77) Cameroon, Czech Republic, United Arab Emirates, (78-79) Macedonia, Lebanon, (80-82) Peru, Saudi Arabia, Vietnam, (83-84) Iraq, Qatar.

IV. PRESIDENTS (1962-2015)

From 1962-1965 Sven Benner (Sweden) served as Acting President. Since then 17 Presidents from 9 countries have been elected to serve the Organization every 3 years. In chronological order:
(1)Val Mayneord (UK), (2) John S Laughlin (USA), (3) R I Magnusson (Sweden), (4) R Mathieu (Canada), (5) John R Mallard (UK), (6) Alexander Kaul, (Germany), (7) Lawrence H Lanzl (USA), (8) John R Cunningham (Canada), (9) Udipi Madhvanath (India), (10) Keith Boddy (UK), (11) Colin Orton (USA), (12) Oskar Chomiski (Poland), (13) Azam Niroomand-Rad (USA), (14) Barry Allen (Australia), (15) Fridtjof Nusslin (Germany), (16) K. Y. Cheung (Hong Kong), (17) Slavik Tabakov (UK)

V. SECRETARIES-GENERAL (1962-2015)

From 1962-1965 John R Mallard (UK) served as Acting Secretary-General. Since then 9 Secreties-General from 4 countries have been elected to serve the Organization for 3 or 6 years. In chronological order:
(1) B Waldeskog (Sweden), (2) John R Cameron (USA), (3) Rune Walstam (Sweden), (4) Brian Stedeford, (UK), (5) Colin Orton (USA), (6) Hans Svensson, (Sweden), (7) Gary Fullerton (USA), (8) Peter Smith (UK), (8) Madan Rehani (Austria)

VI. TREASURERS (1994-2015)

Up to 1994 the Secretary-General looked after the finances of the Organization. From 1994-1997 Ann Dixon-Brown (UK) served as an Honorary Treasurer. Since then 5 Treasurers from 4 countries have been elected to serve the Organization for 3 or 6 years. In chronological order:
(1) Gary Fullerton (USA), (2) Nisakorn Manatrakul (Thailand), (3) George Mawko (Canada), (4) Slavik Tabakov (UK), (5) Anchali Krisanachinda (Thailand)

VII. MAJOR ACCOMPLISHMENTS OF THE IOMP

During the past 50 years the IOMP has achieved all its objectives, and more. Following is a brief summary of these accomplishments:

- Has helped many countries develop national societies and regional organizations and now has 84 National Members and six Regional Organizations
- Established Medical Physics World to communicate with Members
- Organized 20 International Conferences on Medical Physics
- Affiliated with the International Federation of Medical and Biological Engineering to form the International Union for Physical and Engineering Sciences in Medicine (IUPESM)
- Through the IUPESM has gained Full Membership in ICSU
- Joined the International Union of Pure and Applied Physics as Affiliated Commission for Medical Physics
- Worked with the International Labor Organization to gain inclusion of medical physicists in the International Standard Classification of Occupations
- Organized 34 educational and training programs in developing countries and regions
- Established Medical Physics Libraries in developing countries: there are currently 87 libraries in 48 countries
- Established a Used Equipment Donation Program for developing countries
- Established *Medical Physics International* as the Official Journal of the IOMP

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1. John Mallard. *The Birth of the International Organizations - with memories by Prof. John Mallard*. http://www.iomp.org/?q=content/published-history
This article is a modified version of the plenary lecture first given by John Mallard at the Golden Jubilee congress of the HPA/IPSM in Bristol on 8th September 1994. Reprinted in entirety (Scope, Vol. 3 No.2, 25-31, June 1994) with the permission of the author and publisher.

IOMP PROFESSIONAL AND EDUCATIONAL ACTIVITIES

THE HISTORY, DEVELOPMENT, AND REALISATION OF MEDICAL RADIATION PHYSICS EDUCATION IN SWEDEN

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Abstract— **This paper describes the history of Swedish medical radiation physics education and gives details of the core curriculum of today's 5-year specialised medical radiation physicist programme, which fulfils the need to educate clinical physicists with versatile basic knowledge and skills who are well prepared for professional life in all sub-areas of medical radiation physics and radiation protection. The education of medical radiation physics in Sweden has traditionally had a high international reputation, and goes back as an academic education to the mid-1950s.**

'Medical Physicist' became a protected professional title and a state-registered health care profession in 1999. Physicists must now hold a licence to practise any sub-area of the profession, that is, diagnostic radiology, nuclear medicine, magnetic resonance tomography, or radiation therapy. In addition, the medical physicist must obtain expert skills and knowledge in radiation protection of both ionising and non-ionising radiation.

The university departments at Gothenburg, Lund, Stockholm and Umeå Universities, have the authority to award a degree of Master of Science in Medical Physics. These departments have in close symbiosis with their respective university hospitals developed the education programmes over more than 50 years, aim to produce qualified medical physicists with expertise in all the fields of medical radiation physics to meet the changing needs of the health-care sector and society at large. The programmes also provide a good academic grounding and a scientific approach, preparing graduates for a future research career.

Keywords— **medical physicist, medical physics, education, health care profession, Sweden.**

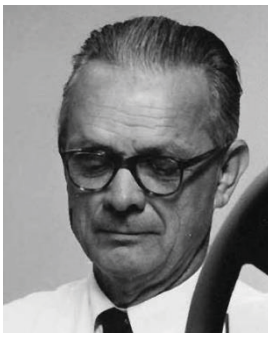
I. The long road to becoming a health care profession

The early use of X-rays beginning in the early 20th century for diagnostics and radiotherapy, as well as the introduction of radium for treatment, were developments that relied on the empirical work of radiology pioneers. Some collaboration took place with physicists in industry, manufacturing equipment, applicators, and instruments. However, the rapid increase in the use of radiation made it necessary to have radiation physics expertise in house at hospitals, a fact that was early recognised in Germany, England, and the United States, and soon afterward in Sweden. In early 1920, Rolf Maximilian Sievert (1896–1966) was employed at the 'Radium Home' (Radiumhemmet), or Radiotherapy Department at Stockholm University, which had been founded 10 years earlier by the surgeon Johan Berg and the oncologist Gösta Forssell [1]. Sievert started his new employment in a modest five-square-metre physics laboratory, and without any salary in the first years (though he was fairly wealthy, since he was the son of a successful industrialist in Germany). Over the years, the size of his department increased, along with its momentous influence on the development of radiotherapy, dosimetry, and radiation protection. Sievert is undoubtedly the 'father of radiation physics' in Sweden, and is honoured worldwide by the adoption of his name for the unit of equivalent and effective dose, the Sievert (Sv).

In 1941, Sievert's laboratory became the Department of Radiation Physics of Stockholm University, with a professorship in the Faculty of Medicine and with a national responsibility for radiation protection. The same year, the first Swedish radiation protection law was agreed on by the Riksdag (the Swedish parliament), and the Department of Radiation Physics was responsible for interpretation of and adherence to the law until the National Institute for Radiation Protection was established in 1965. A similar development and academic status of radiation physics followed at Lund University, under Professor Kurt Lidén (1915–1987), at the University of Gothenburg, by Professor Sven Benner (1900–1986), and some years later at Umeå

Rolf Sievert (1896–1966)
Stockholm

Kurt Lidén (1915–1987)
Lund



Sven Benner (1900–1986)
Gothenburg

Fig. 1 Three pioneers in many fields of radiation physics and radiation protection, and also the initiators of the education of hospital physicists in Sweden during the 1950s.

University, by Professor Gunnar Hettinger (1931–2007). All these departments were and are well integrated with the clinical radiation physics departments at the respective university hospitals, and have a shared academic affiliation to the Faculties of Medicine and Science at their institutions.

Medical physics grew considerably during the 1950s, and the need for a more formal academic society with a wider circle of members with interest in the field became increasingly evident. In 1954 the Swedish Hospital and Health Physicist Society was founded. Later, in 1961, this Society was split into a scientific organisation, the Swedish Society of Radiation Physics [2] and a trade union, the Swedish Hospital Physicists Association [3]. Some of the members of the primary society, mainly the professors Sievert, Lidén, and Benner (Fig. 1), played substantial roles in the continuing development and extension of radiation physics in Sweden during the rest of 1950s, for example in the production of a list of suggested equipment for a medical radiation laboratory, the first programme syllabus for studies in radiation physics, official contact with the authorities on the need for medical physicist positions in hospitals, and the initiation of discussion on medical physics as a health care profession in Sweden. In addition, Sven Benner had a major interest in worldwide dissemination of advances in medical physics; he was a strong supporter of the IOMP, the International Organization for Medical Physics, and was its interim chairman before its formal inauguration in 1963.

The increasing use of ionising radiation in medicine and healthcare required educated and trained clinical physicists at hospitals. The very first documented course syllabus for studies in radiation physics was produced jointly by the Universities of Gothenburg, Lund, and Stockholm at the early date of 1955. Initially, special exemption was needed for every student that wanted to study radiation physics, since it was not yet accepted as an ordinary academic degree. In this first syllabus, different definitions of radiation physics were addressed:

- *General radiation physics*, which deals with the physical basics of ionising radiation and interaction with matter;
- *Technical radiation physics*, which deals with the physics and techniques of radiation sources and measurement technology;
- *Radiation biophysics*, which deals with the physical course of events at the interaction between ionising radiation and biological materials,
- *Clinical radiation physics*, which concerns the medical use of ionising radiation for diagnostics and therapy of patients; and
- *Radiation protection physics*, which deals with the harmful effects of radiation on human beings and how they can be prevented.

It was concluded that it would be ideal to bring these branches together into one subject, radiation physics or radiophysics, not only because they belong to the same field of science but also for practical reasons. All these branches require access to similar, costly, and sometimes unique technical equipment and their practical uses are connected and inform one another. In addition, clinical radiation physics builds on results from biophysical radiation research and requires expertise in technical radiation physics, as well as constant awareness of radiation protection. The physics of radiation protection was declared essential to biophysical radiation research, as were technical radiation physics, and biological radiation effects from experience in clinical radiation physics. These are statements that more or less hold even today. The core of medical radiation physics

education in Sweden today is dosimetry, dose and image optimisation and radiation protection, irrespective of the branch of the field in question, and the main focus of the core curriculum of the unique medical radiation physics programmes in Sweden.

The rapid research and development of medical physics have positively influenced education in the field. In 1965, it was only possible to study a few individual courses in radiation physics, parallel to physics and mathematics. A few years later, in 1970, radiation physics became its own ordinary examination subject with additional course content focused on the medical use of ionising radiation. In 1980, basic radiation physics was studied through a serious of courses during one-year and a half-year of clinical courses, after two years' studies in basic physics and mathematics, for a total of 3.5 years, corresponding to today's 210 ECTS-points, the European Credit Transfer System. The syllabi and design of courses during this period were very much influenced by two former senior lecturers and directors of studies, Bo Nilsson at Stockholm University and Sven-Erik Strand at Lund University. In the mid-1980s a one-year Master of Science programme was introduced and medical physics education increased to 240 ECTS, which is 160 weeks including 20 weeks' thesis work. This was the situation until the introduction of a licence to practise and state regulation of medical physics as a health care profession in Sweden on 1 January 1999, after years of persistent proposals to the government from the Hospital Physicists Association. The education was extended by an additional term (20 weeks) committed to clinical training and professional development.

As part of the Bologna Process, the series of ministerial meetings and agreements between European countries designed to ensure comparability in the standards and quality of higher education qualifications, Sweden in 2006 implemented the joint European three-cycle system as a qualification framework in higher education [4]. However, the professional programmes were first excluded, but after months of persistent deliberation with the Ministry of Education and Research, the Swedish Parliament agreed to a prolongation of the medical physics programme to five years (corresponding to 300 ECTS) on 26 April 2006. The details of the core curriculum of this programme are given below.

II. Age and gender distribution

Medical physicists in Sweden traditionally specialise in the fields of medical *radiation* physics and radiation protection, that is, fields that involve radiation but normally excluding ultrasound and bioengineering. As recounted above, the academic education tradition in medical physics goes back to the late 1950s. At that time, the number of physicists in medicine was only 30 in the whole country, but by the time the licence to practise was introduced in 1999, almost 40 years after the first proposal to receive status as a health care profession, the number of medical physicists was just above 200, and by the beginning of 2006 this had increased to around 350. By May 2013, the number had further increased to 570 registered and fully qualified licensees, as recognised by the National Board of Wealth and Healthcare. The rapid increase since 1999 is probably linked to the establishment of the status of medical physics as a health care profession, the increased visibility of medical physics in society, the active recruitment of students, and education of schoolteachers to help them integrate basic medical physics into their teaching of fundamental physics concepts [5]. About 450 physicists (full-time equivalents) are working clinically, and the rest are at universities, authorising bodies (e.g. the Swedish Radiation Safety Authority), or in private industry. Their principal fields of activity in medicine and healthcare are radiotherapy (RT), 37%; nuclear medicine (NM), 23%; diagnostic radiology (DR), 19%; magnetic resonance imaging (MRI), 11%; and mixed activities (e.g. NM/MRI, NM/DR), 10%. Almost all medical physicists also have radiation protection as a field of responsibility.

The current age and gender distribution of Swedish medical physicists is presented in Table 1. It is notable that professionals in the field today are fairly young, with 50% younger than 40 years; of these, 45% are women, while of the profession as a whole about 38% are women. Since the population in Sweden is 9.56 million, the number of clinically working medical physicists per million inhabitants is about 45, but of course a concentration is present in city areas hosting university hospitals, as seen in Figure 2. For instance, in the county of Skåne (the location of Lund University), there are nearly 10 physicists per 100,000 inhabitants, while in the counties of Västra Götaland (University of Gothenburg) and Stockholms län (Stockholm University), there are about seven.

Table 1 Age and gender distribution of medical radiation physicists. Figures include staff at universities, authorising bodies, and the private sector (as of March 2013). In Sweden, the retirement age is 65 years with the legal right to work to an age of 67 years.

Age Interval	Fraction	Number	
		Men	Women
< 30 years	19.6%	63	43 (41%)
30–34 years	17.1%	54	43 (44%)
35–39 years	13.3%	36	36 (50%)
40–44 years	15.5%	55	29 (35%)
45–49 years	11.6%	38	25 (40%)
50–54 years	7.6%	26	15 (37%)
55–59 years	5.0%	21	6 (22%)
60–65 years	7.0%	31	7 (18%)
66–67 years	2.6%	12	2 (14%)
All ages		336	206 (38%)
> 67 years (retired)		31	8 (20%)

III. Competencies and functions

The National Board of Health and Welfare has published the document 'Competencies for Medical Physicists', giving a more detailed description of and guidelines for the profession [6]. The Board states that:

'*As an expert on radiation and radiation protection in medical care, the medical physicist co-operates in the use of ionising and non-ionising radiation. The medical physicist's occupational field comprises patients – children, youth, adults and elderly people – who in different medical disciplines and areas in a hospital or any other medical field, are examined or treated by radiation-based diagnosis (diagnostic radiology, nuclear medicine or magnetic resonance imaging) or radiation therapy or are undergoing any other analysis, diagnosis, or treatment with ionising non-ionising radiation (e.g. ultrasound, UV light, microwaves, and laser light). The medical physicist works on radiation protection for patients and personnel and on radiation protection of the general public and the environment*.'

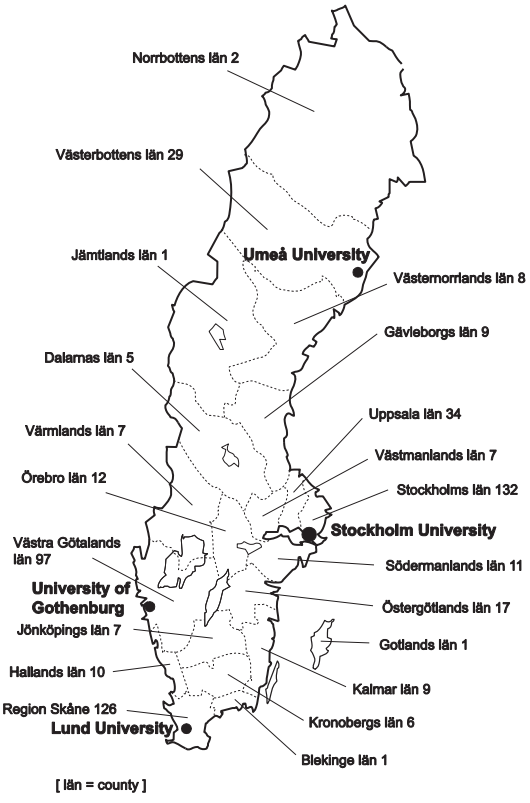


Fig. 2 The number and county distribution of Medical Physicists with License to Practise in Sweden, March 2013. Source: National Board of Health and Welfare.

IV. Degree and learning objectives

Responsibility for higher education in Sweden rests with the Swedish Higher Education Authority. A description of the goals for a Master of Science in Medical Physics is given in the Higher Education Ordinance (1993:100), §32, '*Sjukhusfysikerexamen 300 hp'* (300 ECTS), that is, the Degree of Master of Science in Medical Physics [7]. The national learning goals under this ordinance are divided into *i*) *knowledge and understanding, ii*) *skills and abilities*, and *iii*) *judgment and approach*, and are as follows:

Scope

A degree of Master of Science in Medical Physics is obtained after the student has completed course requirements consisting of 300 higher education credits.

Objectives

For a degree of Master of Science in Medical Physics, students must demonstrate the knowledge and skills required for certification as a medical physicist.

Knowledge and understanding

For a degree of Master of Science in Medical Physics, students must

- *demonstrate knowledge of the scientific basis of the field and insight into current research and development work, together with knowledge of the connection between science and proven experience and the significance of this connection for professional practice;*
- *demonstrate both broad and deep knowledge of physical, biological, and technical aspects of radiotherapy and image and functional diagnostics, together with the application of this knowledge in the health services;*
- *demonstrate knowledge of planning, leading, and coordination in the professional field; and*
- *demonstrate knowledge of relevant legislation, particularly in the area of radiation protection.*

Skills and abilities

For a degree of Master of Science in Medical Physics, students must

- *demonstrate a deep ability to independently apply mathematical and scientific methods in all activities involving radiation in health and medical services;*
- *demonstrate an ability to exercise responsibility for and carry out necessary quality-assurance work concerning both equipment and working methods in activities involving radiation;*
- *demonstrate an ability to integrate knowledge from relevant areas and to independently and critically analyse, assess, and deal with complex phenomena, issues, and situations;*

- *demonstrate an ability to develop, use, evaluate, and optimise new methods in the area;*
- *demonstrate an ability to initiate, plan, lead, coordinate, and evaluate preventive radiation protection work in health and medical services, for both staff and patients;*
- *demonstrate an ability to engage in teamwork and cooperation with other professional groups, together with an ability to provide information and training to staff in radiation protection work; and*
- *demonstrate an ability to provide information about and discuss new facts, phenomena, and issues with different groups, orally and in writing, in both national and international contexts, so as to contribute to the development of the profession and of professional activities.*

Judgment and approach

For a degree of Master of Science in Medical Physics, students must

- *demonstrate self-knowledge and a capacity for empathy;*
- *demonstrate a capacity to make assessments based on a holistic approach to the human person and on relevant scientific, social, and ethical aspects, paying particular attention to human rights;*
- *demonstrate an ability to take a professional approach to patients and their family members;*
- *demonstrate an ability to identify ethical aspects of their own research and development work; and*
- *demonstrate an ability to identify their need for further knowledge and continuously upgrade their capabilities.*

Independent project (degree project)

For a degree of Master of Science in Medical Physics, students must have completed an independent project (degree project) worth at least 30 higher education credits, within the framework of the course requirements.

Other

For a degree of Master of Science in Medical Physics, more precise requirements also apply as determined by each higher education institution itself, within the framework of the requirements in this qualification description.

V. Symbiosis between education, research, and clinical experience

Medical physics education and degrees are regulated not only by the Higher Education Authority but also by the Universities, which work in very close symbiosis with the clinical medical physics departments at their respective university hospitals. The four major universities – Gothenburg, Lund, Stockholm, and Umeå – all have the authority to award a degree of a Master of Science in Medical Physics. The degree qualifies the physicist for a licence to practise. Students normally apply directly from upper secondary school to the medical physics programme, beginning with an emphasis on physics and mathematics. The number of study places in Sweden as a whole is approximately 48 per year (12 per programme).

The university studies are divided into two years of basic physics and mathematics and three years of medical radiation physics, and like studies for all health care professions, they include clinical training and a MSc thesis. The respective programmes at the four universities have fairly similar curricula and syllabi. In a national evaluation 2007, the Swedish Higher Education Authority ranked the medical physics programmes as one of the best health care professional training programmes in Sweden, due to the high quality of the theses, the many senior lecturer and professors, and also clinically active hospital physicists with strong scientific skills and competences, and the close connection to on-going research, which is embedded in the teaching.

The four Departments of Medical Radiation Physics have responsibility for specialised medical physics education, which in each case is a joint programme between the Faculties of Science and Medicine. The core curriculum of the programmes aims to produce qualified medical physicists who are competent and secure in their professional role and able to act independently, and who possess the necessary knowledge, skills, and approaches to meet the changing requirements of the healthcare sector and society at large. As in almost all health care professions in Sweden, clinical training is integrated within the university programmes, which also aim to provide a good academic grounding with a scientific approach in preparation for a future professional career. Specifically, the programmes shall provide the students with the necessary research skills, both in theory and practice, to prepare them for third-cycle studies (usually a PhD degree).

Teaching is divided into lectures, individual and group projects, group discussions, student seminars, point-/counterpoint discussions, laboratory work, and clinical training. Emphasis is given to the student's own independent activities, peer-review of student's projects, and reflections, and a considerable portion of the learning activities is based on real, everyday problems and cases. This means that beyond expert knowledge in medical physics, there is a requirement that academic teachers, as well as instructors and lab work supervisors (senior clinical medical physicists), are pedagogically skilled. Most laboratory work is carried out using the hospitals' clinical equipment and devices. Twenty weeks are set aside for clinical training in the hospital's medical physics department and related departments such as nuclear medicine, including nuclear pharmacy and cyclotron production of radionuclides; diagnostic radiology; magnetic

resonance; and radiation therapy. Special syllabi have been developed for this training in collaboration with clinical physicists to make sure that it includes the most essential tasks in everyday clinical work.

For the degree of Master of Science in Medical Physics, more precise requirements apply, as determined by each higher education institution within the framework of the Higher Education Ordinance. As exemplified by the curriculum at Lund University, they are as follows. Each graduated medical physicist, as a medical physics expert in both ionising and non-ionising radiation for health services and the community, within their professional field, shall:

- *be able to contribute to the optimisation of image and functional diagnostics, using their specialised knowledge and understanding of processes in medical physics, in order to ensure the best possible investigative and/or treatment results with the least possible risk of injury to the individual or society*;
- *have a subject specialisation which, together with good knowledge of radiological statutes, facilitates work in radiological protection, research, and development, primarily within healthcare, but also for society in general*;
- *exercise leadership within their professional field and promote the development of new methods, the introduction of new equipment, quality assurance, optimisation, and preventive radiological protection for both staff and patients*;
- *adopting a professional approach towards patients and their relatives as a member of staff, be able to provide information about any radiological risks involved in the various examinations and treatments, as well as being able to educate various professional groups in health and medical care on the topics of radiological protection and optimisation*;
- *be able to identify problem areas; analyse, formulate and propose measures to address them on a scientific basis; and reassess them on the basis of new scientific evidence*;
- *have the ability to inform the general public about the use of ionising and non-ionising radiation, its significance for society, and the risks radiation entails*; *and*
- *with their knowledge and understanding of the occurrence of radioactive substances and radiation's consequences for people, animals, and the environment, be able to analyse problems and to formulate and carry out measures in the case of radiological incidents or catastrophes*.

These objectives are achieved through broad and deep academic studies and training in the various areas upon which the subjects of medical radiation physics and radiation protection are based. Although there may exist differences between the four education programmes and the courses they include, the more than about 150 detailed learning outcomes for compulsory courses as stated in the respective syllabi are quite similar.

VI. Programme course flow

As mentioned above, the four programmes are nearly identical and specify the same learning outcomes, but some differences exist concerning course flow. For the first two years, students study in Departments of Physics and Mathematics, and from the fifth term, in Departments of Medical Radiation Physics located at the university hospitals. After completing the core curriculum and passing the examinations, the graduated student can apply for a licence to practise from the National Board of Health and Welfare. Medical physicists who pass the examination are registered by this authority as fully qualified medical physicists (QMP) and experts in radiation physics. The course flow and content of the programme at Lund University are given in Table 2.

Table 2 Course flow (Lund University).

First and second years: Basic Physics and Mathematics	
Term 1 (1–30 ECTS) 20 weeks	**Physics 1: General course in Physics, 30 higher education credits.** *Mechanics and Electro-magnetism. Waves, optics, quanta, energy and experimental projects).*
Term 2 (31–60 ECTS) 20 weeks	**Mathematics: Analysis 1, 15 higher education credits.** *Linear equation systems. Matrices. Analytical geometry in three dimensions. The basic sets of continuity of functions of one variable. Integrals. Taylor's formula. Generalised integrals and series. First- and second-order standard differential equations and their applications.* **Mathematics: Algebra 1, 15 higher education credits.** *Basic characteristics of integral numbers and real numbers. Induction. Combinatorics. Polynomials and algebraic equations. Cartesian coordinate system in plane and linear equations. Complex numbers. The function concept. The elementary functions. Numerical sequences. Elementary one-variable analysis comprising limits and continuity, derivatives, and curve construction.*
Term 3 (61–90 ECTS) 20 weeks	**Physics 2: Mathematical Tools in Science, 30 higher education credits.** *Mathematical and computational tools; numerical tools. Quantum mechanics. Laboratories and project work.*
Term 4 (91–120 ECTS) 20 weeks	**Physics 3: Modern Physics, 30 higher education credits.** *Atomic and molecular physics. Nuclear physics and reactors. Solid-state physics. Particle physics, cosmology, and accelerators.*

Third year: Radiation Physics and Medical Radiation Physics

Terms 5–6 (121–180 ECTS) 40 weeks	**Medical Radiation Physics, Basic Radiation Physics, 60 ECTS.** *Production and interaction of ionising radiation – theory (10). Radiation detectors and measuring methods – theory (6). Problem-solving – production, interaction, and detectors (6). Radiation dosimetry (8). Medical terminology and fundamental principles (7). Radiation biology (7). Non-ionising radiation (9). Radioecology and general radiation protection (7).*

Fourth year: Medical Radiation Physics

Term 7–8 (181–240 ECTS) 40 weeks	**Medical Radiation Physics, Medical Physics, 60 ECTS.** *Digital image processing and its mathematics (9). Physics of ultrasound (3). MR-physics (8). Physics of radiology (8). Physics of nuclear medicine (12). Physics of radiation therapy (16). Biostatistics (4).*

Fifth and final year: Medical Radiation Physics

Term 9 (241–270 ECTS) 20 weeks	**Clinical Training and Legislation, 30 ECTS.** *Medical ethics (3). Legislation (3). Clinical training and professional development (24).*
Term 10 (271–300 ECTS) 20 weeks	**Master's Degree Project in Medical Radiation Physics, 30 ECTS.**

VII. Postgraduate education and training

Postgraduate education and continuing professional development (CPD) is mainly a responsibility of the profession itself, and is coordinated by the Swedish Society of Radiation Physics and the Swedish Hospital Physicist Association. These associations work together with the universities and the departments of medical physics to promote postgraduate education and CPD on the basis of EFOMP guidelines [8] and especially on the requirements of the Swedish healthcare system.

A CPD programme was established in 2005 and curriculum developed to implement a five-year training period leading to qualification as a 'specialised medical physicist'. In addition to this CPD effort there are also periodic programmes for PhD students, which are of interest for clinically working physicists as well. The PhD programme covers four years, with one-and-a-half years of full-time theoretical studies and around two-and-a-half years devoted to the dissertation. A PhD is generally required for higher positions in the field, and at about 40% of Swedish medical physicists hold a PhD degree.

VIII. Final remarks

The foundation of Swedish medical physics education and the field's status as a state-registered health care profession was laid down more than 50 years ago by the pioneers Rolf Sievert, Kurt Lidén, and Sven Benner (the last, one of the initiators of the IOMP). Today's specialised regiment of medical radiation physics education builds on a long tradition where teaching is closely connected to clinical activities and research. The curriculum provides the medical physicist with broad, deep knowledge and adequate skills for employment as a qualified medical physicist with license to practise and an expert in radiation protection.

Acknowledgment

This paper is dedicated to my former and present colleagues, with whom I have had the privilege to work for many years, and not least to all the students who have become competent, skilful medical physicists with expert knowledge. Together, their persistent efforts have built a leading medical physics education system closely connected to clinical experience and research in all fields of medical radiation physics, as well as a proud tradition in radiation protection.

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A STUDY WITH EUROPEAN PROFESSIONAL SOCIETIES ON MEDICAL RADIATION PROTECTION EDUCATION AND TRAINING

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Abstract— **As part of the MEDRAPET European Commission project, a web-based survey was implemented to obtain information from European professional and scientific societies and organizations whose members are working with ionizing radiation on a daily basis regarding the status of radiation protection education and training of their members. The overall response rate was 25.3%. The majority of medical physics, radiology, radiography, nuclear medicine and radiation oncology societies stated that they organize courses focused on radiation protection for their members. A limited number of interventional radiology societies (33%) provide such courses for their members. Continuous professional development courses should be provided for all medical professions working with ionizing radiation, especially for health professionals involved in fluoroscopically-guided procedures.**

I. INTRODUCTION

Medical exposures constitute a considerable source of radiation exposure to human population (1). It is well known that the per capita radiation exposure from medical examinations has increased significantly during the last decades. Medical examinations responsible for this increase are mainly CT and fluoroscopically-guided procedures. Several international organizations recognize the importance of education and training in medical radiation protection (1-8). The European Commission initiated the MEDRAPET project (MEDical RAdiation Protection Education and Training, MEDRAPET) to a) perform a study on the implementation of the Medical Exposure Directive requirements (9) on radiation protection training of medical professionals in the EU Member States and b) update the existing European Guidance (8), containing appropriate recommendations at EU level on harmonization of radiation protection education in the medical field. The professional organizations involved in MEDRAPET include the main European stakeholders and professional groups involved with radiation protection training in the medical field i.e. the European Society of Radiology (ESR), the European Federation of Organizations for Medical Physics (EFOMP), the European Federation of Radiographer Societies (EFRS), the European Society for Therapeutic Radiology and Oncology (ESTRO), the European Association of Nuclear Medicine (EANM) and the Cardiovascular and Interventional Radiological Society of Europe (CIRSE).

As part of the MEDRAPET project, an EU-wide study has been conducted in order to obtain a view regarding radiation protection education and training of medical professionals in Europe. The current work presents the results of an on-line questionnaire developed to obtain information from European professional and scientific societies and organizations whose members are working with ionizing radiation on a daily basis regarding the status of radiation protection education and training of their members.

II. MATERIALS AND METHODS

A web-based survey was accomplished through development of an online questionnaire including 9 questions. The questionnaire was decided to have an online format in order to facilitate the collection/analysis of responses, and to ensure a high level of user-friendliness. All relevant categories of health care staff were considered in the study, including referrers, practitioners (diagnostic radiology specialists, radiotherapy specialists, nuclear medicine specialists, interventional specialists, dental doctors etc.), radiographers, medical physicists, nurses. In total, the entire study population comprised of 509 professional societies. Table 1 shows the number of professional societies targeted in the current study for each profession.

Questions were put together following discussions with representatives of the MEDRAPET consortium members and members of the advisory committee of the project. The questionnaire included questions related to training in radiation protection of each professional society members; accreditation of courses; evaluation of legal provisions on radiation protection training of medical professionals in different EU Member States; role of professional societies in the organization and promotion of radiation protection education and training courses; input of organizations on curricula in radiation protection education and training programs. A question on topics essential to medical radiation protection was also included in the questionnaire. The table of topics as defined by ICRP (2) was used in this survey with some additions relevant to the use of new

technologies, radiotherapy and nuclear medicine. In total, 25 topics were included, defined as ICRP and MEDRAPET topics. Table 2 lists all questions included in our questionnaire.

Table 1. The number of professional societies per profession which were targeted in this study.

Professional Society	Number of contacts
Cardiologists	23
Dentists	34
Emergency Doctors	25
Gastroenterologists	29
General practitioners	27
Interventional Cardiologists	1
Interventional Radiologists	23
Medical Associations	32
Medical Physicists	47
Neurosurgeons	1
Nuclear Medicine physicians	33
Nurses	26
Orthopaedic Surgeons	26
Pediatricians	31
Radiation Oncologists	29
Radiographers	47
Radiologists	34
Urologists	30
Vascular Surgeons	11

The questionnaire was piloted in order to identify possible mistakes or questions being misunderstood. The pilot survey was carried out from mid-June 2011 to mid-August 2011. Table 3 shows the national professional societies involved in the pilot study. A pre-survey announcement was sent to all survey participants as a measure to maximize response rate. For the same reason, a regular reminder scheme during the running time of the survey was established. Thus, a reminder was sent twice per week to the non-respondents in order to maximise response rate. In addition, personal follow-up by telephone calls were made to the target groups in order to increase turnout. All recipients were informed of the study purpose. The web-based survey was conducted from September 13 to the October 31, 2011.

Table 2. Questions to obtain information from European professional and scientific societies whose members are working with ionizing radiation on a daily basis regarding the status of radiation protection education and training of their members and possible answers.

Question	Possible answers
1. How do you classify the practical training in radiation protection of your members?	Good Adequate Inadequate None
2. If you answered good, adequate or inadequate in the last question, is the practical training in radiation protection certified by:	Your national radiation protection authority Your society Other organization Not certified
3. Is the practical training in radiation protection a national legal requirement?	Yes No
4. Is the practical training in radiation protection given during:	Undergraduate courses During residency/clinical placements CPD courses
5. Does your society promote courses in radiation protection for its members?	Yes No
6. Does your society organize courses in radiation protection for your members?	Yes No
7. Has your society been asked to give input on curricula in radiation protection education and training developed for your members by health or other authorities or organizations?	Yes No
8. Does your current national legislation adequately address the needs of education and training in radiation protection for your members?	Yes No
9. Please identify the topics in your curriculum regarding radiation protection education T1- Atomic Structure, X-ray production and interaction of radiation T2- Nuclear structure and radioactivity T3- Radiological quantities and units T4- Physical characteristics of the X-ray machines T5- Fundamentals of radiation detection T6- Fundamentals of radiobiology ,biological effects of radiation T7- Risks of cancer and hereditary disease and effective dose T8 - Risks of deterministic effects T9 - General principles of RP T10- Operational RP T11- Particular patient RP aspects T12 - Particular staff RP aspects T13- Typical doses from diagnostic procedures T14- Risks from foetal exposure T15- Quality control and quality assurance T16- National regulations and international standards T17- Dose management of pregnant patients T18- Dose management of pregnant staff T19- Justification of imaging examinations	Not included Partially included Fully included

T20- Dose optimization in digital radiographic and fluoroscopic techniques. T21-Dose optimization in computed tomography T22-Dose optimization in diagnostic and therapeutic procedures with unsealed radionuclides. T23- Biokinetics of incorporated radionuclides T24-Treatment plan optimization and strategies for maximizing the therapeutic ratio T25-Target volume-confined (conformal) irradiation in a radiation protection perspective	

Table 2. The national professional societies and countries involved in the MEDRAPET pilot study.

Professional Society	Country
Medical Physicists professional society	Italy
Radiographers professional society	Slovenia
Radiation Oncologists professional society	Norway
Radiologists professional society	United Kingdom
Nuclear Medicine Physicians professional society	Netherlands
General Practitioners professional society	Italy

III. Results

There were 129 responses with an average response rate of 25.3%. The response rate was high for societies representing professions directly involved with the use of ionizing radiation. Specifically, the response rate was 67.7% for radiologists, 51.1% for radiographers, 46.8% for medical physicists, 42.4% for nuclear medicine physicians and 41.4% for radiation oncologists. However, the response of interventional societies was relatively low. Thus, the response rate for interventional radiologists and vascular surgeons was 26.1% and 18.2% respectively. There were 11 responses from dental societies with a response rate of 32.4%. Results from professions with less than 5 responses are not presented in this work.

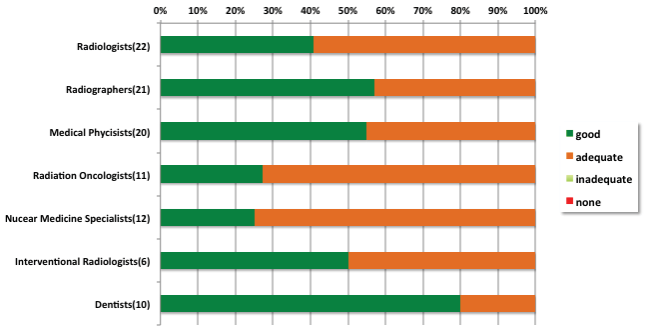

Figure 1. Graph showing answers to question 'How do you classify the practical training in radiation protection of your members?''.

All professional societies stated that the practical training in radiation protection of their members is good or adequate (Fig. 1). Eighty percent of dental societies classify the practical training in radiation protection of their members to be good.

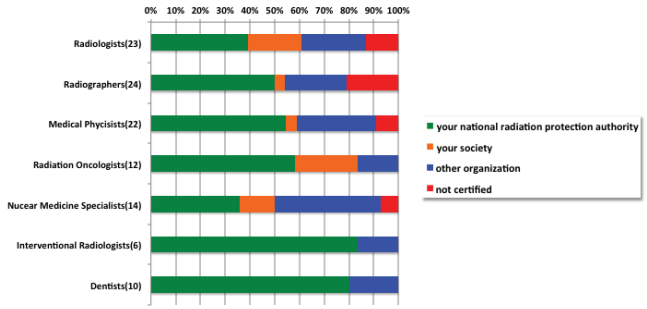

Figure 2. Graph showing answers to question 'If you answered good, adequate or inadequate in the last question, is the practical training in radiation protection certified by a) your national radiation protection authority, b) your society, c) other organization, d) not certified'. '

Corresponding percentages for nuclear medicine physicians and radiation oncologists were less than 24% and 26%. Most societies confirmed that practical training is certified by an organisation, the majority being certified by radiation protection authorities. Only a small percentage (8%-21%) of radiologists, radiographers, medical physicists and nuclear medicine physicians' professional societies stated that there is no certification whatsoever in radiation protection practical training (Figure 2).

Figure 3. Graph showing answers to question 'Is the practical training in radiation protection a national legal requirement?

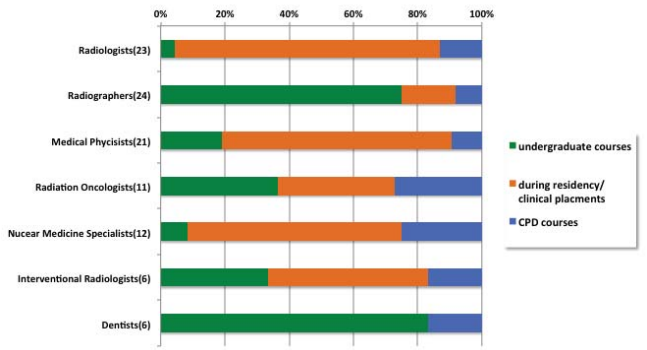

Figure 4. Graph showing answers to question 'Is the practical training in radiation protection given during a) undergraduate courses, b) during residency/clinical placements, c) CPD courses'

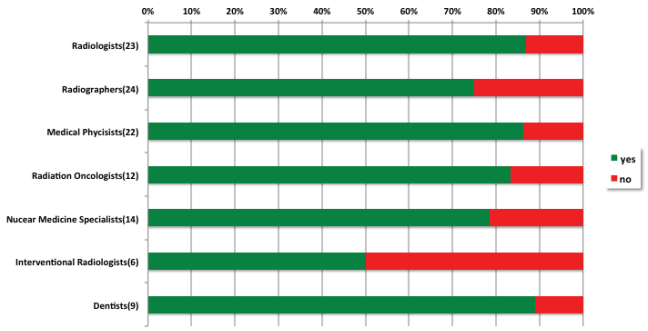

Figure 5. Graph showing answers to question 'Does your society promote courses in radiation protection for its members?

On average 72.4% of societies confirmed that practical training in radiation protection is a national legal requirement in their country (Fig. 3). Medical professionals and medical physicists obtain their practical training in radiation protection mostly during residency/clinical placements, while radiographers receive training during their undergraduate courses (Fig. 4). The majority of societies stated that they promote courses in radiation protection. Surprisingly, only 50% of interventional radiology societies said that promote such courses, despite the fact that the members of these societies receive relatively high doses of radiation (Fig. 5).

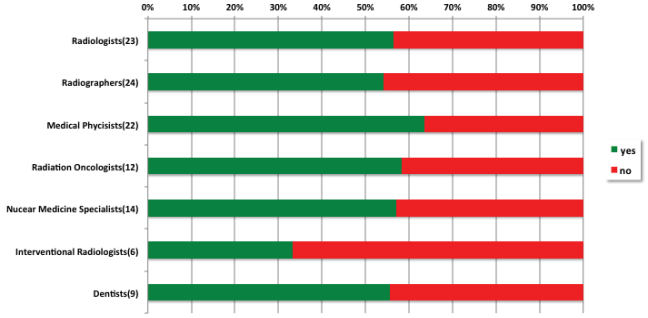

Figure 6. Graph showing answers to question 'Does your society organize courses in radiation protection for your members?

Figure 6 shows the percentage of societies that organise courses in radiation protection. Interventional radiology societies were those with the lowest percentage for this question (33%). More than 50% of professional societies have been asked to contribute to curricula in radiation protection by health or other authorities or organizations (Fig. 7). Seventy five percent of medical physics societies gave a positive answer to this question. This result indicates a higher involvement of medical physics professional societies compared to other professional societies in giving input on radiation protection curricula. The majority of professional societies (over 60%) consider their national legislation to adequately address the needs of their members in radiation protection education and training (Fig. 8).

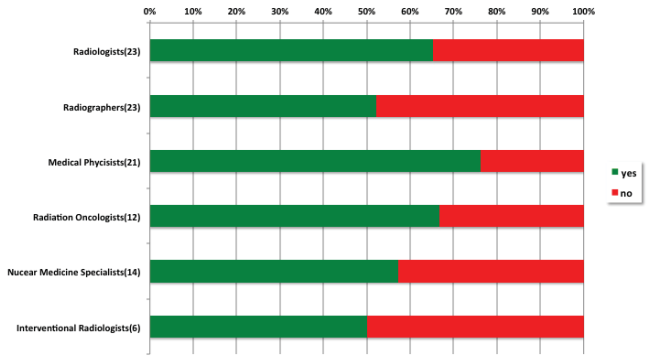

Figure 7. Graph showing answers to question 'Has your society been asked to give input on curricula in radiation protection education and training developed for your members by health or other authorities or organizations?

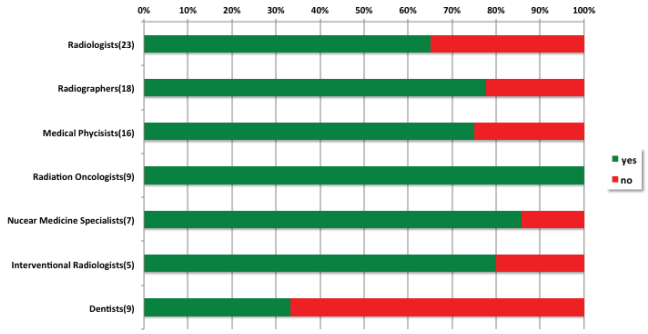

Figure 8. Graph showing answers to question 'Does your current national legislation adequately address the needs of education and training in radiation protection for your members?'

Figure 9 shows the mean percentage of ICRP and MEDRPAPET topics included in the curriculum of 7 professions. Results indicate that interventional radiologists have included the minimum number of radiation protection topics in their curricula.

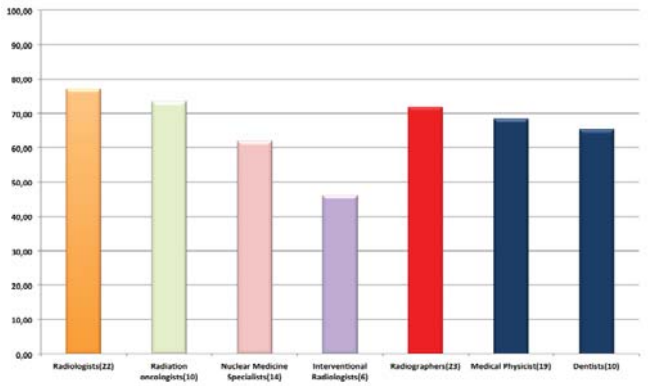

Figure 9. Percentage of ICRP and MEDRPAPET topics included in the curriculum of 7 professions

IV. Discussion

Education and training in medical radiation protection is of great importance for all medical professions and especially for those working directly with ionizing radiation. Fluoroscopically-guided procedures are associated with high radiation doses not only to patients but also to personnel. This study shows that interventional radiologists lack curricula and dedicated training in radiation protection. Continuous professional development (CPD) courses should be provided for all medical professions working with ionizing radiation, especially for health professionals involved in fluoroscopically-guided procedures. There were societies of certain professions with no or minimum interest in responding to our questionnaire. Among the societies of this category were societies with members that perform fluoroscopically-guided procedures such as the societies of cardiologists (23 contacts, 0 responses), gastroenterologists (29 contacts, 0 responses), orthopedic surgeons (26 contacts, 2 responses) and vascular surgeons (11 contacts, 2 responses). Interventional cardiologists, vascular surgeons, gastrointestinal endoscopists and orthopaedic surgeons that perform fluoroscopically guided procedures require basic and dedicated training in radiation protection.

The MEDRAPET project has developed the European Guidance on radiation protection education and training containing recommendations on harmonization in this field (10). This Guidance document provides a structured Knowledge-Skill-Competence (KSC) table model according to the European Qualifications Framework (11) and provides adequate coverage of requirements and guidance for new specialists using ionising radiation, in particular those outside imaging departments. Detailed KSC inventories have been produced for all health care professions. They are structured within a novel curriculum development framework and key activities thus directly linking curriculum content to professional role. The structure of this document will facilitate future amendments and the inclusion of new professions. Additionally, a permanent multidisciplinary working party will draft and maintain European standard sets of competences at various levels for minimum Radiation Protection training and continuous professional development required for all different groups of medical staff working with ionising radiation.

Figure 6 shows that many societies representing medical specialities directly associated with the use of ionizing radiation do not organize courses on radiation protection. We believe that, on a national level, the main reasons for the absence of specific training schemes are financial, and there is lack of academic staff specialized in all aspects of medical radiation protection. Professions working with ionizing radiation require educational and training platforms suitable for radiation protection teaching. These platforms are not generally available in the EC member States. Networks of excellent of teaching centres should be created that will develop high level radiation protection courses to bring health care professionals to the required scientific level. An effort should be made to increase CPD courses in radiation protection education and training for all professions and specialities. A European body for accreditation in medical radiation protection is needed to promote radiation protection by evaluating and accrediting graduate, residency and CPD courses focused on medical radiation protection. The MEDRAPET European Guidance provides the standards for external assessment of radiation protection courses. Projects should be initiated to provide the best possible training opportunities to the European professionals involved in medical radiation procedures. These projects should transform the learning outcomes identified in the MEDRAPET European Guidance into specific programmes of advanced education and training and CPD.

The majority of professional societies consider national legislation to adequately address the needs of their members in radiation protection education and training (Fig. 8). A high percentage of dental societies (70%), however, consider national legislation to be inadequate regarding education and training in radiation protection (Fig. 8). The introduction of a radiation protection course in the basic curriculum of medical and dental schools has been made mandatory recently in the revised Euratom BSS (draft version) and this is very encouraging (12). However, support in the implementation of the legislative requirements related to radiation protection education and training of health care professionals is needed. Universities, training institutions, radiation protection authorities, health authorities, scientific and professional societies, hospitals, educational authorities, international organizations and equipment manufacturers may all have an important role in the promotion, organization, certification, accreditation, support of the training activities in radiation protection for medical exposures. There is a need to build a bridge between these institutions, authorities and organizations in order to achieve the goals of EC directives concerning medical exposure.

Acknowledgments

The research leading to the results presented in this article has received funding from the European Commission (Project ENER/D4/212-2010 ‘Study on the Implementation of the Medical Exposure Directive’s Requirements on Radiation Protection Training of Medical Professionals in the European Union’). The authors wish to acknowledge the following MEDRAPET members for their contribution to the project: Peter Vock, ESR, Natasa Brasik, ESR, Carmel J. Caruana, EFOMP, Jim Malone, EFOMP, Sija Geers-van Gemeren, EFRS, Dean Pekarovic, EFRS, Wolfgang Eschner, EANM, Andrea Bauer, EANM, Dag Rune Olsen, ESTRO, Mary Coffey, ESTRO, Efstathios Efstathopoulos, CIRSE, Dimitrios Tsetis, CIRSE, Robert Bauer, CIRSE,

Gabriel Bartal, CIRSE, Christos Liapis, ESVS, Madan, Rehani, IAEA, Maria del Rosario Perez, WHO, Ruzica Maksimovic, WHO, Annemarie Schmitt-Hannig, BfS, Ritva Bly, HERCA, Keith Horner, UK, Jackie Brown, UK.

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MEDICAL PHYSICS ORGANISATIONS

MEDICAL PHYSICS IN CANADA

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I. Historical Perspective

Medical physics has a long and illustrious history in Canada. Röntgen discovered X rays in November 1895 and the first medical use of X rays in Canada occurred soon thereafter in early February 1896 at McGill University in Montreal and at the University of Toronto. Becquerel discovered natural radioactivity in 1896 and Rutherford carried out his seminal work on radioactivity at McGill University during the early years of the 20-th century. These events laid the foundation for medical use of X rays and radioactivity in Canadian clinical and academic institutions, generated employment for physicists in Canadian medical centres, and paved the road for eventual formation of Canadian medical physics organizations.

Many physics departments across Canada had already during the 1930s and 1940s made significant contributions to efforts in making the use of ionizing radiation in medicine safe and efficient. There were many pockets of significant early contributions to medical physics spread across Canada; however, none of them was as important, far-reaching, and visionary as the programs developed by Harold E. Johns, first in Saskatoon and then in Toronto. Dr. Johns completed his Ph.D. studies in Physics at the University of Toronto and his first job was with the University of Saskatchewan and the Saskatchewan Cancer Commission in Saskatoon.

While in Saskatoon in the late 1940s and early 1950s, Dr. Johns invented the cobalt-60 teletherapy machine for cancer therapy, built the first such machine for clinical use, and developed a first rate medical physics graduate program. This program trained many graduate students who upon graduation made significant contributions to medical physics in their own right and formed the early links in Johns's medical physics dynasty, now already extending into five generations.

In the mid 1950s Johns moved to Toronto accompanied by some of his former graduate students. Together with medical staff they built the Princess Margaret Hospital (PMH) and the University of Toronto into pre-eminent and world-renowned centres for radiotherapy and medical physics. The research carried out by PMH staff and students was at the forefront of medical physics and Dr. Johns' book "The Physics of Radiology" which he co-authored with his former student and colleague Dr. John R. Cunningham, is still considered, after four editions, the most authoritative and complete text on radiological physics. Dr. Johns had a profound influence on the practice of medical physics in Canada and its current high standards can to a large extent be attributed to his vision and dedication to the medical physics profession.

The year 1980 was a watershed year in Canadian medical physics. Notably, Harold Johns' retirement that year forced a redistribution of leadership in the Canadian medical physics community. Several other important events also took place during that year which helped to distribute the concentration of Canadian medical physics away from Toronto and the PMH to other centres across Canada: (1) the Canadian College of Physicists in Medicine was formed, (2) several new radiotherapy centres were established and many older centres were expanded or rejuvenated, (3) several new graduate education programs in medical physics were inaugurated, and (4) the X-ray section of the National Research Council (NRC) in Ottawa was reorganized and its dosimetry work expanded.

After 1980 medical physics service, teaching, and research spread rapidly to major provincial centres across Canada. Canadian imaging physics also underwent a major expansion, most notably with the opening of the Robarts Research Institute in London, Ontario and the Reichman Research Institute in Toronto, both staffed with many eminent medical physicists who proved that radiotherapy physics was not the only exciting and important branch of contemporary medical physics.

Toward the end of the 1980s many senior medical physicists believed that radiotherapy physics was a completed discipline with exhausted research opportunities and that imaging physics became the most innovative area of research in medical physics. However, the early 1990s proved that this sentiment was premature considering the explosion in radiotherapy physics research engendered during that period by rapid advances in treatment planning, technology of dose delivery, and imaging for radiotherapy. The advent of the CT-simulator, intensity modulated radiotherapy, and image guided radiotherapy has significantly increased the complexity of dose delivery in radiotherapy and highlighted the importance of medical physics in imaging and treatment of cancer.

In recent years, the new technological developments in dose delivery caused the convergence of imaging and radiotherapy physics and introduced the PET functional imaging to radiotherapy. Just like during the introduction of medical use of ionizing radiation in diagnosis and treatment of disease more than a century ago, Canada of today offers its population state-of-the-art technological developments in imaging as well as in radiotherapy, and medical physicists form an important component in development and delivery of these services.

II. Treatment Technology and Techniques

The Canadian approach to cancer therapy is focused on provincial cancer foundations. This approach, despite some practical drawbacks, has enabled Canadian institutions to build relatively large cancer therapy centres with an assortment of modern equipment and a critical mass of medical physicists. Access to state-of-the-art imaging and therapy equipment is of benefit not only to patients but also to medical physicists who, in addition to gaining the most up-to-date practical experience, can carry out applied research on modern and sophisticated imaging and dose delivery equipment. For example, the installation of a third generation 25 MV clinical linac in Toronto in the early 1970s stimulated research into the basic properties of high-energy X-ray and electron beams used clinically. Another example is Winnipeg that, during the 1980s gained a worldwide reputation as an important centre for portal imaging research.

Since the invention of cobalt-60 teletherapy during the 1950s, Canada has maintained its position on the forefront of radiotherapy and medical physics. As a result of a strong collaboration between physicians and medical physicists in large Canadian cancer hospitals several new imaging and treatment techniques were developed in Canada and rapidly translated into clinical use. Examples of Canadian innovations are half-body and total body photon irradiation as well as cone beam imaging developed in Toronto and moving beam techniques, such as rotational total skin electron irradiation and dynamic stereotactic radiosurgery, developed in Montreal.

III. Medical Physics Organizations

The first Canadian national medical physics organization was formed in 1955 as the Division of Medical Physics (DMP) under the auspices of the then 10-years-old Canadian Association of Physicists (CAP). The DMP developed its own constitution and objectives, obtained funding through individual CAP members who opted to join and pay dues to the division, and met annually as a component of the CAP congress at the time and location chosen by the CAP.

For a number of years this arrangement was satisfactory; however, with the ever-increasing growth of the DMP membership, it became apparent that an independent organization of Canadian medical physicists would offer more flexibility and better funding opportunities. This sentiment eventually prevailed in 1989 and lead to the formation of the Canadian Organization of Medical Physicists (COMP) that is independent from the CAP, has its own constitution, by-laws, membership requirements, and head office, organizes its own annual meetings, and funds its operation through membership dues and proceeds from annual meetings and exhibits.

The COMP seamlessly continued the medical physics tradition of the original DMP-CAP and during the past two decades grew into a very strong national medical physics organization that is well respected nationally as well as internationally and maintains strong links to the International Organization for Medical Physics (IOMP), the American Association of Physicists in Medicine (AAPM) as well as the CAP. Current COMP membership stands at 511, producing a rate of 15 medical physicists per million people in Canada. Considering that the mean rate of medical physicists per million people in the World is about 3, the rate of 15 ranks Canada among highly developed countries in the medical physics domain.

An elected 10-member board chaired by the President runs the COMP with support from an Executive Director and administrative staff. In addition to various standing and ad-hoc committees, the COMP has a prestigious awards program with the COMP Gold Medal its highest honour. The COMP also bestows Fellowship upon selected senior medical physicists and endorses the Sylvia Fedoruk Prize in medical physics that is sponsored by the Saskatchewan Cancer Agency and recognizes the best medical physics research paper that originated in Canada in a given calendar year. Jointly with the CAP, the COMP sponsors the Peter Kirkby Memorial Medal for outstanding service to Canadian physics.

As part of its annual meeting the COMP conducts a highly successful young investigators' symposium. The symposium competition, a highlight of annual meetings, is named in honour of John R. Cunningham, a highly respected and decorated Canadian medical physicist.

IV. Certification of Medical Physicists

In order to deal with professional issues specific to medical physicists the Canadian College of Physicists in Medicine (CCPM) was formed in 1980 with a mandate to organize procedures for professional certification, continuing education, and maintenance of certification for Canadian medical physicists. The original "grandfathers" of the CCPM were six senior medical physicists from across Canada: S.O. Fedoruk, A.F. Holloway, H.E. Johns, J.C.F. MacDonald, R.M. Mathieu, and M.E.J. Young.

The CCPM certifies medical physicists on two levels. The CCPM Membership level is attained through a written and oral examination aimed at establishing candidate's competence for work in medical physics; the advanced level CCPM Fellowship is attained through a rigorous oral examination of candidates holding the rank of senior medical physicist. An eight-member board chaired by the President runs the CCPM; the chief examiner and the examination board run the examination process, and the COMP and examination fees provide funding for the CCPM.

The minimum requirements for admission to CCPM Membership examination are an advanced degree in Physics (preferably in the medical physics specialty) and 2 years of clinical experience. A CCPM Member can apply for CCPM Fellowship examination upon completing 7 years of clinical experience. Currently, the CCPM comprises 235 Members and 161 Fellows, highlighting the high degree of professional certification among Canadian medical physicists with 396 Member or Fellow certifications among the 511 COMP members.

V. Accreditation of Medical Physics Educational Programs

To promote and ensure quality of academic programs in medical physics the American Association of Physicists in Medicine (AAPM) started to offer formal accreditation of medical physics academic programs in 1988. The first U.S. institutions with accredited programs in medical physics were the University of Wisconsin in Madison and Wayne State University in Detroit, both accredited in 1988; the first Canadian institution with such an accreditation was McGill University in 1993.

During the 1990s the responsibility for accreditation of medical physics educational programs was transferred to a new independent commission, referred to as the Commission on Accreditation of Medical Physics Educational Programs (CAMPEP) that is currently sponsored by five organizations. In addition to the AAPM and the COMP, the organizations sponsoring the CAMPEP are: the American College of Radiation Oncology (ACRO), the American College of Radiology (ACR), and the Radiological Society of North America (RSNA). Currently the CAMPEP accredits the following educational programs in medical physics: M.Sc., Ph.D., radiation oncology physics residency, imaging physics residency, certification of didactic coursework in preparation for residency, and continuing education.

With regard to accreditation Canadian medical physics educational programs are doing well considering the population ratio of 9 : 1 between the U.S. and Canada. Of the 43 graduate programs currently accredited by the CAMPEP, nine (21 %) are in Canada; of the 64 radiotherapy residency programs, 8 (12.5 %) are in Canada, and of the 8 imaging residency programs, one (12.5 %) is in Canada.

VI. Medical Physics Research and Innovation

Medical physics research and innovation have a strong tradition in Canada and plenty of role models, most notably in Harold Johns and a number of his contemporaries who were active in medical physics during the 1950s through 1970s. One of the benefits of the Canadian model of nationalized health care delivery is that it resulted in a concentration of cancer therapy in large hospitals in major Canadian cities. This, in turn, produced the formation of relatively large medical physics departments with a critical mass of medical physicists that are involved not only in service work but also with teaching and applied research.

The respectable research productivity by Canadian medical physicists is evident from the "Medical Physics" journal, the official science journal of the AAPM with co-sponsorship by the COMP and the CCPM. To every five articles in "Medical Physics" originating from U.S. institutions there is, on the average, one article that originates in Canada. This ratio exceeds significantly the population ratio between the two countries, and simply reflects better opportunities for medical physics research in a few larger medical centres of Canada in comparison with a large number of relatively small physics operations with no protected research time that are prevalent in the U.S.

VII. Canadian versus American Medical Physics

A unique characteristic of Canadian medical physics is its strong collaboration with the AAPM. The AAPM has close to 8000 members and 440 of these are Canadians, members of the COMP, and work in Canadian institutions. From its formation in 1958 the AAPM accepted Canadians with full membership rights and privileges and one can find Canadian members on the AAPM Board of Directors, various councils, committees, task groups and as recipients of various AAPM honours and awards. The relationship between Canada and the U.S. as far as medical physics is concerned is truly exemplary and of obvious benefit to both sides. It is notable that, on the average, every 10 years the AAPM holds its annual meeting in Canada jointly with the COMP. These meetings are always memorable and strengthen the ties between the two organizations and the two countries.

While the AAPM benefits from the contribution of Canadian members, the AAPM also provides Canadians with a world-class medical physics forum; over ten times the size of the COMP. It turns out that Canadian medical physics measures up in this forum quite well. For example, to date Canadian medical physicists won 34 % of the Farrington Daniels awards (13 of 38) and 24 % of the Sylvia Sorkin-Greenfield awards (7 of 29). The AAPM bestows the two awards annually for the best articles published in "Medical Physics" journal, respectively, on the subject of radiation dosimetry and on any other medical physics subject with the exception of radiation dosimetry.

Canadian medical physicists also won 10 % of the highest-honour awards that the AAPM bestows on an AAPM member, the Coolidge award (4 of 40). Another source of pride for Canadian medical physics is the performance of Canadian medical physics graduate students in the John R. Cameron Young Investigators' Symposium held during the annual AAPM meetings. Of the 10 students, who are admitted to the oral competition based on their abstract as well as supporting documentation and then present their talk in the competition, typically three students are from Canadian institutions and at least one of them typically finishes among the three winners of the competition.

VIII. Conclusions

Canada has the distinction of being in the group of the four inaugural countries that in 1963 sponsored the formation of the International Organization for Medical Physics (IOMP). The other three countries are the U.K., Sweden, and the U.S. This year, as we celebrate 50 years of the IOMP, Canada's medical physics remains strong, providing excellent clinical service in imaging and radiotherapy, carrying out respectable research and innovation, and providing great educational opportunities for young physicists who aspire to a rewarding career in medical physics.

The main characteristics of Canadian medical physics are summarized as follows:

1. High level of professionalism;
2. Strong national medical physics organizations;
3. Professional certification process run by medical physicists for medical physicists;
4. Excellent graduate and residency teaching programs spread across Canada;
5. Excellent research and innovation productivity; and
6. Concentration of clinical and academic medical physics programs in relatively large centres across Canada, providing a critical mass of medical physicists.

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EDUCATIONAL RESOURCES

PHYSICS EDUCATION FOR THE OPTIMIZATION OF MRI CLINICAL PROCEDURES: VISUALIZING THE INVISIBLE AND COLLABORATIVE TEACHING

P. Sprawls
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Abstract— **Magnetic Resonance Imaging (MRI) is capable of producing high-quality images permitting visualization of a variety of tissue characteristics and fluid movement that reveal signs of pathology along with evaluations of normal conditions and functions. It is a procedure in which image characteristics and quality are controlled through a complex combination of adjustable protocol factors that must be set for each patient examination. The selection of factor values that provide an optimized protocol requires a knowledge of the physics principles by the radiologists and other members of the clinical imaging team. Medical physicists contribute to image quality and effective diagnostic procedures by providing educational opportunities within their institutions. Their role and contribution is enhanced through the process of collaborative teaching and the use of MRI educational resources available online with open access.**

Keywords— **MRI, Image Quality, Physics Education, Collaborative Teaching, Open Access.**

I. Introduction and overview

Magnetic resonance imaging (MRI) is a highly effective clinical diagnostic method because it produces images that provide visualization of a variety of tissue characteristics and fluid movement that relate to physiological function and show signs of disease. This extensive capability as a diagnostic method comes from the ability to adjust the image characteristics for maximum visibility of many different conditions within the patient body. However, this is not without a major challenge: the complexity of the imaging procedure because of the many variable factors that must be set and adjusted for each patient examination. Each procedure is controlled by a protocol consisting of many factors that have been set for that particular patient. MRI systems are programmed with many pre-set protocols that can be selected by the operator based on anatomical site and clinical objective such as possible diseases and this provides a starting point for each procedure.

A higher level of performance and image quality is the goal of *optimizing* the protocols by the intelligent interaction of the clinical staff, generally radiologists in collaboration with the technologists who operate the equipment. This requires a comprehensive knowledge of the physics and physical principles of the MR process. It is this knowledge and understanding of physics concepts that can be provided by clinical physicists associated with the MRI facility and medical physics educators.

The variation and potential problems with MR image quality in all countries of the world is usually associated with how the equipment is operated. A significant contribution to MR image quality control and assurance is an educated clinical team, radiologists and technologists, who understand and can apply the physics.

In this article we review the types of physics knowledge that are needed in clinical MRI and the learning experiences and types of teaching that can contribute to the development of that knowledge. We then consider the quality characteristics of MR images-- their general relationship to procedure protocols and the concept of protocol optimization-- and then identify the important physics concepts that apply. The significance of visualization in the learning process is emphasized.

Highly effective physics education to support clinical MRI can be achieved in all institutions through the process of collaborative teaching and shared educational resources .This is supported by comprehensive resources (text and visuals) with open access at: http://www.sprawls.org/mripmt/ A special emphasis is to provide resources for physicists who are not generally working in MRI to enable them to be more involved and contribute physics knowledge to support clinical activities.

II. Physics learning experiences and clinical imaging outcomes

A major objective of physics education for radiologists and other members of the medical imaging team, is to enable them to analyze, evaluate, and develop creative solutions to guide the imaging process and derive maximum clinical information from images. This requires higher levels of knowledge well above just memorized facts and other forms of verbal information. The development of this level of knowledge depends on the type of learning experience that is available to them as illustrated in Figure 1.

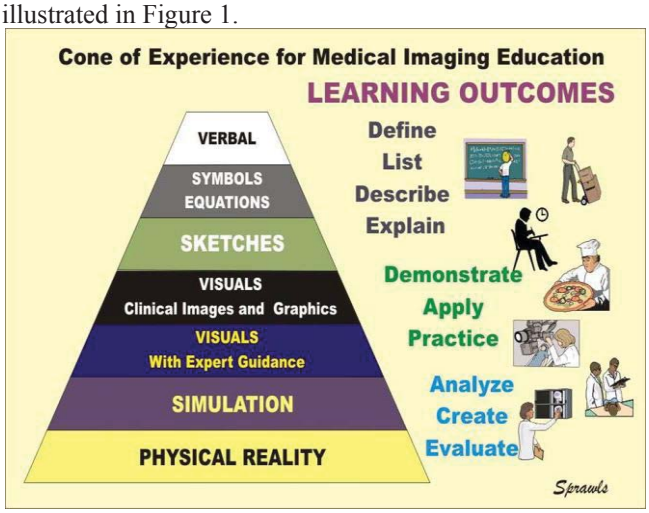

Figure 1. The general relationship between learning outcomes and the types of learning experiences and teaching methods represented by the "Cone of Experience" on the left.

Edgar Dale (1900 – 1985) was the pioneer who developed the *Cone of Experience* to describe the different types of learning activities and teaching methods that are arranged in the form of a cone. This has been published in many forms that can be found by doing a web search on his name. The great value in this organization of learning and teaching activities is this.

A. Efficient Teaching

The learning experiences and teaching methods near the top of the cone are generally quite *efficient*. Compared to the lower ones, they require much less effort and expense to conduct. Standing up and giving a verbal lecture and maybe writing equations on the board is much less demanding that conducting an interactive physics learning activity directly in the clinic.

B. Effective Teaching

The learning experiences at the bottom of the cone are more *effective* in producing outcomes and knowledge that can be applied in the process of medical imaging.

. C. The Challenge

A major challenge in education, especially for clinical medical physics, is providing learning activities that are *effective* and also enable radiologists to interact with the imaging process, understand image characteristics, and optimize procedures to obtain the required clinical information.

A problem we are facing in medical physics education around the world is the separation between the classroom (in which learning occurs) and the clinical environment (in which the knowledge needs to be applied). It is just not practical or efficient with respect to the cost of human effort and facilities to conduct most physics teaching directly in the clinic.

D .Visualizing the Invisible

The higher levels of knowledge that contribute to creative thinking, analysis, problem solving, etc. are greatly enhanced by the ability to visualize the physical phenomena or physical reality that is being worked with. An advantage with learning in the clinic is the ability to observe images, the patient and the imaging process that produces the images, and to interact with the imaging procedure. This contributes to effective learning but there is a limit to what can be viewed. All medical imaging methods, including MRI, are based on much that is invisible. This includes radiation, magnetic fields, and the interactions within the patient body that produces the images.

The invisible can be made visible for learning and teaching with the use of visuals that are created to show not only the invisible physical universe but also relationships and how it is all combined to form complex imaging procedures. It is not practical, or even possible, for every teacher to draw on the board, or produce in other forms, all of the required visuals for the effective teaching of MRI physics. The solution is *collaborative teaching*.

II. Collaborative teaching

An appropriate concept and definition of teaching is that it is helping someone learn. It is not a transfer of knowledge from one brain to another. Rather it is providing an environment and conditions where the learner can experience the part of the physical universe that is being studied with guidance in observing, analyzing, and interacting with the physics. Collaborative teaching is when two or more medical physicists combine their contributions to the learning process as illustrated in figure 2.

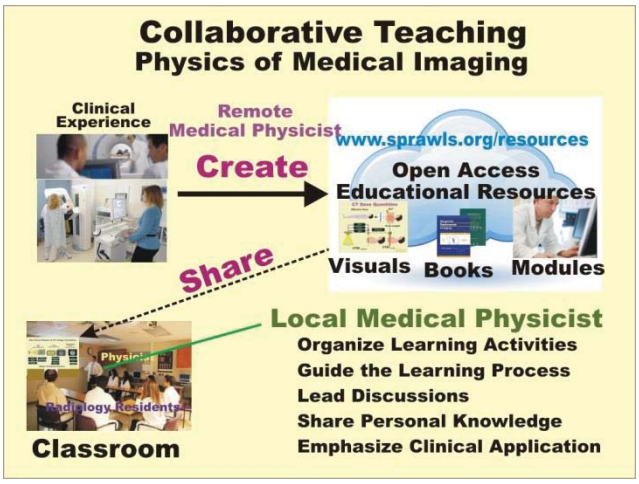

Figure 2. The two phases of collaborative teaching--first, the creation and distribution of visuals and related resources; followed by guiding the learning process in the classroom.

A .Creating and Sharing Visuals and Related Resources

Visuals provide a "window" through which the physical universe can be observed and studied from the classroom or during any other learning activity. The creation of effective visuals is a major effort requiring extensive knowledge and experience in the subject, such as the physics of clinical MRI, along with the ability and resources to transform the knowledge into visual formats. When this is done and shared with open access it then makes it possible for teachers in all institutions to devote their efforts to organizing and guiding highly effective learning activities. It enhances both the *effectiveness* and the *efficiency* of the total teaching process.

B. Conducting Effective Classroom Learning Activities

Medical physicists in various institutions around the world can provide a major contribution to effective and safe medical imaging procedures by providing educational activities for radiologists and other medical imaging professionals. Even when their experience does not include clinical MRI applications their knowledge of general medical physics combined with the appropriate visuals and related resources provided here enables them to conduct high-quality class or small-group discussions and learning activities.

III. MR IMAGE QUALITY CHARACTERISTICS

The starting and point of focus for MR physics education for medical personnel is the *image*, not the spinning protons! That comes later. The image is what the radiologists see, interact with, and use to connect to the human body. It is the information contained in the image that is important. One of the first goals of physics education is to help understand the image characteristics that can affect information and then how it can be controlled.

The one comprehensive characteristic that determines image quality and displayed information is *visibility*. More specifically, can the radiologist see the anatomical structures, tissue characteristics, fluid activity, and signs of pathology to make an accurate diagnosis. While visibility is an image characteristic it varies with objects and structures within each image generally depending on their biological or molecular composition and their size. The general image quality and visibility of specific structures and objects is determined by the combination of five (5) more specific image characteristics shown in Figure 3.

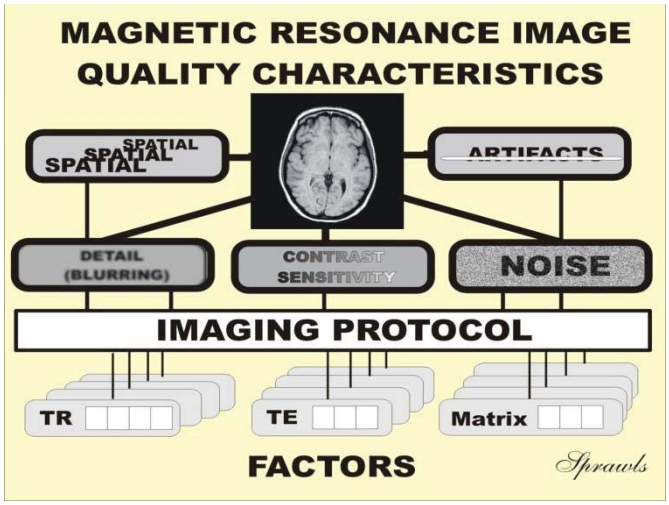

Figure 3. The five characteristics of an MR image that determine its general quality and visibility of specific anatomical structures and objects.

The critical issue in MR imaging is that each of these image quality characteristics can be, and should be, adjusted for optimum visualization in each clinical procedure. This adjustment is through a complex relationship with the many protocol factors. To understand the image characteristics, the relationship to the protocol factors, and the process of optimization, requires an extensive knowledge of physics.

A. Contrast Sensitivity

Contrast sensitivity is the most significant adjustable characteristic associated with the MR imaging process that determines visibility of specific tissue differences based on their magnetic characteristics. The three (3) magnetic characteristics-- proton density (hydrogen concentration), and the two relation times, T1 and T2, are the sources of physical contrast within the body. The first step in producing and enhancing visibility of tissue differences based on each of these characteristics is to select an appropriate imaging method (often referred to as the pulse sequence) and then to set the optimum values

for protocol factors such as TR and TE. While all facilities have a good selection of pre-set protocols, knowledge of physics is essential for understanding why specific values are used and if protocols are optimized, especially with respect to image acquisition time.

B .Detail

Size is a characteristic of some anatomic structures or objects that might limit their visibility because of the blurring that occurs during the imaging process. This determines the visibility of detail within the image. While visibility of detail is the important characteristic for clinical imaging and diagnosis it is the characteristic that physicists often know as spatial resolution. Both visibility of anatomical detail and spatial resolution as measured with test objects are determined and limited by the same thing, blurring.

Blurring is present in all medical imaging procedures and for the most part related to design characteristics of the imaging equipment and certain parameters of the imaging process such as focal spot size and receptor design in radiography. In MRI the source of blurring is primarily the size of the tissue voxel formed during the imaging process as illustrated in Figure 4.

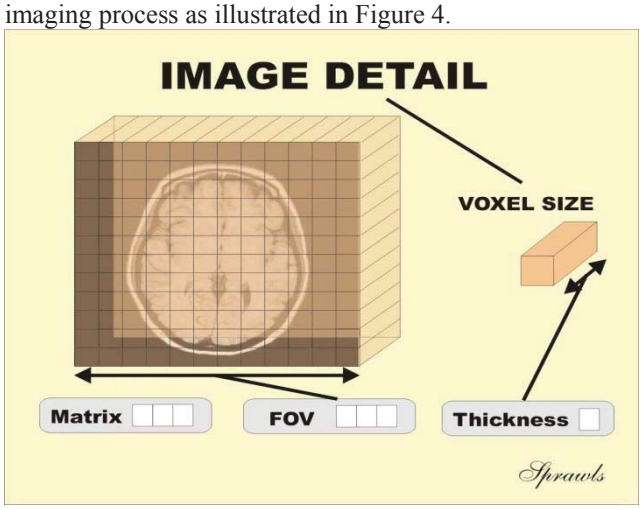

Figure 4. The protocol factors that control voxel size which determines blurring and visibility of detail in MR images.

A tissue voxel is actually a three-dimensional blur with all structures within it "blurred together" and represented by one pixel in the image. We cannot see any detail within a voxel, just an image showing a matrix of voxels. Image detail can be increased by reducing voxel size through the adjustment of the three protocol factors.

This now brings us to an interesting question….if we can reduce blurring and improve visibility of detail by setting factors to produce smaller voxels why don't we just do it? That opens up the very crucial issue of *protocol optimization!* In MR imaging many of the adjustable protocol factors have an effect on more than one image quality characteristic and other things like image acquisition time. Very often, these are opposing factors which must be balanced in the process of optimization.

In the MR imaging process, specifically in the image reconstruction phase, the patient body is divided into a matrix of discreet samples of tissue, the voxels. As will be reviewed later, the image is composed from a collection of radio-frequency (RF) signals from each of these voxels or tissue samples. This is why voxel size is a major factor that determines image noise.

C. Noise

Visual noise is a generally undesirable characteristic that is present to some extent in all medical images, including MRI. The effect of noise is to reduce the visibility of structures and objects that have relatively low contrast. This is often the small differences among tissues that convey important clinical information.

In an MR image the predominant source of noise is random RF emissions from the total mass of tissue within the sensitive receiving area of the RF coils. While this can be controlled to some extent by selection of coil types (body, head, surface, etc.) and adjusting receiving bandwidth, an effective approach to controlling image noise is by adjusting the strength of the RF signals from the individual tissue voxels. The amount of noise that actually appears in an image is determined by the signal-to-noise (S/N) ratio. It is the desirable signals from the voxels competing with the undesirable noise emissions from the larger mass of tissue as illustrated in Figure 5.

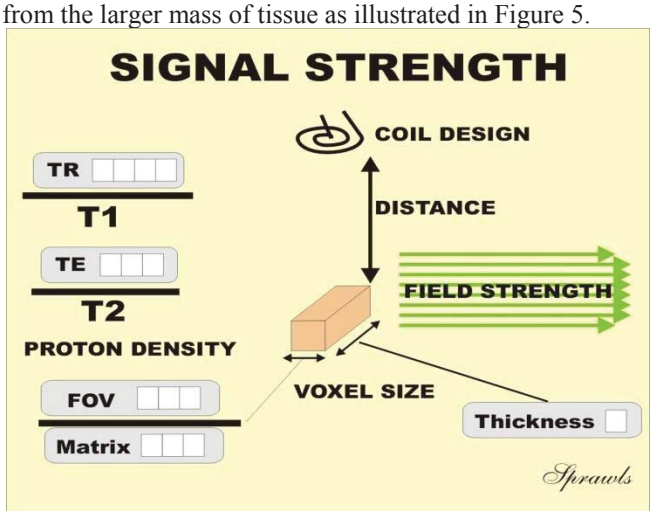

Figure 5. Protocol factors that determine RF signal strength (signal-to-noise) which determines the level of noise in MR images. Here we are emphasizing the significance of voxel size. .

In setting up a protocol for a procedure the noise can be reduced by *increasing* voxel size. Here is the challenge! Increasing voxel size to improve image quality by reducing noise also has the effect of deteriorating image quality by increasing the blurring and reducing visibility of detail.

Assuming the appropriate imaging method (pulse sequence) and associated factors to obtain the required contrast sensitivity have been selected, voxel size *is the predominant factor that must be considered in the optimization of a protocol for a specific clinical procedure. It is a complex issue that requires knowledge of the associated physics principles.*

V. Optimizing voxel size

Effective physics education to support clinical MRI procedure optimization must include a good conceptual understanding of voxels. Voxels should be visualized by the radiologists and technologists as how the body is being sampled and the image formed. The illustrations included here and others in the online resource are useful for that purpose.

The selection of an appropriate voxel size not only involves the conflict between image detail and noise. There is another major factor that must be considered: the *image acquisition time.*

The diagram in Figure 6 is helpful for understanding and communicating this somewhat complex relationship.

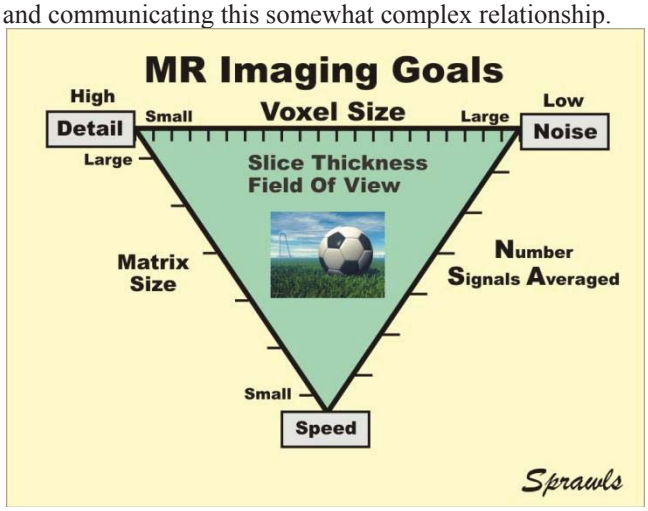

Figure 6. The relationship of image detail, noise, and acquisition time, and the protocol factors that can be adjusted to optimize a procedure.

In an MRI facility the starting point for most procedures is the pre-set protocol for the specific clinical objective. When a specific protocol is selected the major protocol factor values are displayed. With an appropriate knowledge of physics the clinical staff can understand the significance of each of the factors with respect to the image quality characteristics and if the protocol is appropriate for the procedure that is being setup.

And as a next step, with the understanding of the physics principles, the protocol factors can be adjusted to optimize the procedure for the specific patient and clinical requirements.

For each imaging procedure there are specific imaging goals, three of which are identified in the illustration. To understand the complexity and the challenge of optimizing an MR procedure let's compare it to a game of soccer (football). There is a major difference. In soccer our team always has just one goal to get the ball to. In MR imaging we have several different goals and the challenge is that they are in different and opposing directions. We can think of each imaging protocol as being represented by a ball position somewhere on the field. But here is the problem: when we make changes to move closer to one of the desirable goals, for example high detail, we are moving away from some of the other desirable goals including low noise and increased acquisition speed. The optimum "field position" for a specific procedure requires knowledge of the clinical requirements and what needs to be visualized combined with knowledge of the physics and the process of controlling the image characteristics.

VI. Conclusions

MR imaging is a process in which the image characteristics affecting visibility and general quality are determined by a complex combination of adjustable protocol factors. The optimizing of a protocol for a specific patient procedure is enhanced by understanding the physics as it relates to the imaging process.

Medical physicists make major contributions to MR image quality and clinical effectiveness by helping radiologists and the other imaging professionals develop the appropriate knowledge and understanding of the physics concepts. Through the process of collaborative teaching, physicists in all institutions can use resources that are provided with open access on the web to develop and conduct classes and other learning activities that benefit from their individual scope of knowledge and experiences.

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Available with open access at:
http://www.sprawls.org/mripmt/

MEDICAL PHYSICS THESAURUS AND INTERNATIONAL DICTIONARY

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Abstract

The paper describes the development of the first Thesaurus of Medical Physics Terms (currently c. 3500 terms) and its International Dictionary, currently including 29 languages. The Dictionary has been used as a foundation for the development of the EMITEL e-Encyclopaedia of Medical Physics. The project for the development of the Dictionary and its translation has attracted more than 200 senior colleagues. The paper gratefully acknowledges the contribution of all those colleagues, forming the largest international network in medical physics. Currently the Dictionary is one of the main Reference sources in the profession, used by more than 2000 colleagues per month.

I. INTRODUCTION

The quick international dissemination of the e-Learning materials of project EMERALD [1] during the late 1990-ies led to the need of an International Dictionary of Medical Physics. To address this need a sub-task was added to the next project EMIT [2] (an EU Leonardo da Vinci project, 2001-04) for the creation of a Dictionary of Medical Physics – alongside with the development of e-Learning materials in the field of Ultrasound and MR Imaging. Initially the Dictionary had to include 5 main languages (English, German, French, Italian and Swedish), however after the first announcement of the Dictionary a number of colleagues from other countries volunteered to include their languages and by 2013 the Dictionary included 29 languages. A number of papers have described the development of the e-Encyclopaedia of Medical Physics EMITEL [3,4,5]. This papers aims to describe the development of its predecessor and companion – The Medical Physics Thesaurus and International Dictionary.

II. THESAURUS OF MEDICAL PHYSICS TERMS

The first and most difficult task of the Dictionary was to develop a Thesaurus of Medical Physics Terms. To deal with this the Working Group of the partnership selected 20 well known books covering various fields of the profession. All these books were in English and this was the language used for the creation of the Thesaurus. The terms were formed of one or more words (e.g. Dose, Absorbed Dose, Absorbed Dose Conversion Factor, etc). The most important terms from these books were selected and listed in parallel tables. The initial list included almost 15,000 terms in English, but many were repetitions and old terms. Removing those reduced the number to about 8000. Following this the terms were grouped and distributed according to the filed (specialism). This process included the following main steps:

- Merging identical terms;
- Grouping the terms according to their field (large groups);
- Grouping synonyms (and some homonyms) the terms (small groups);
- Identifying other terms (from medicine, physics, chemistry, mathematics, etc) with specific use in Medical Physics;
- Creating a master table (Thesaurus) with Medical Physics Terms.

This way the first Thesaurus of Medical Physics was created, its initial number of terms being 3706. However this number included a small number of repetitions of terms known with their abbreviations (i.e. Modulation Transfer Function co-existed with MTF). At that stage this was necessary for formation of a printed alphabetical index.

Each term from the Thesaurus was assigned an ID number and from this moment all translations were based on the IDs of the English terms. Groups of translators were formed including specialists in the 6 main fields of the professions (Physics of: X-ray Diagnostic radiology, Nuclear Medicine, Radiotherapy, Ultrasound Imaging, Magnetic Resonance Imaging, Radiation Safety). General terms were covered by all translators.

Soon the initial 5 languages were joined by additional translations into Spanish and Portuguese (please see at the end list of the Translation Groups). Parallel tables for each translation were created (aligned as per the term ID), forming a multilingual database. This allowed smooth move from one language to another – i.e. cross-translation between any two languages.

III. EMIT CT DICTIONARY

The need for electronic dissemination of the first Dictionary led to the inclusion of software developers in the team (AM Studio) in 2003. At that stage the development of a further Encyclopaedia was already planned and the interface of the Dictionary was made to be able to display text associated with the respective term from the Thesaurus database (temporarily filled with an image with the logo of the project).

The first e-Dictionary was developed early in 2003 and was engraved on a Mini CD, together with demos of the e-Learning materials EMERALD and EMIT (Figure 1). The Mini CD included an executive file of the Dictionary and required installation on the PC of the user. The interface required selection of the two languages for the translation (from .. to…) and included the necessary fonts. This user-friendly design allowed very easy use of the Dictionary. There were three Dictionary windows: the Left Search window (From), where the user types the term; the Left Display window, which presented a limited list of the respective Language table from the database (from the Input Language); a Right (To) window presenting the translation of the selected text from the Output language (Figure 1). Search was performed in the usual way of handling databases - the user types the first letters of the term in the Left search window and these letters call the respective initial term from the list of terms in the Display window.

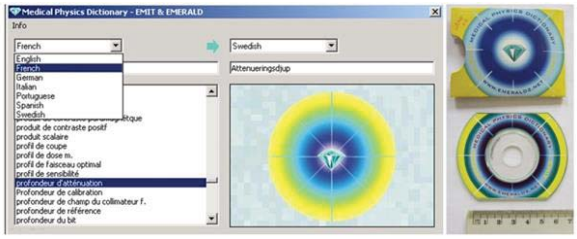

Figure 1. Screen shot of the Mini CD Dictionary and a photo of the CD.

One thousands of these Mini CDs were distributed free during the World Congress on Medical Physics and Biomedical Engineering in Sydney, Australia (August 2003). This distribution of the Dictionary and the Thesaurus of Medical Physics Terms triggered similar ideas for the development of similar Dictionaries in specific languages.

A special Conference (ICTP, Trieste, Italy, 2003) addressed the assessment of the Dictionary and found it extremely useful. This was supported by the use of the Dictionary during the International Medical Physics College on the following year (ICTP, Trieste, 2004). These two events and the World Congress triggered enormous interest in the Dictionary and a number of colleagues from various countries volunteered in the translation of the Thesaurus into their languages.

The novelty and comprehensive content delivered by the EMERALD and EMIT projects, as well as their global impact through our unique International Dictionary of Medical Physics Terms, led to the inaugural EU Leonardo da Vinci Award presented to the team of EMIT project (Maastricht, Netherlands, 2004) [6].

IV. WEB DICTIONARY

The inclusion of new languages in the Dictionary presented new challenges because of the different alphabets, which were difficult to be handled by the existing software. However at that time the current web technologies advanced enough to allow to transfer the Dictionary on the Web. A new domain was registered (www.emitdictionary.co.uk) and the new software was made by AM Studio (Figure 2).

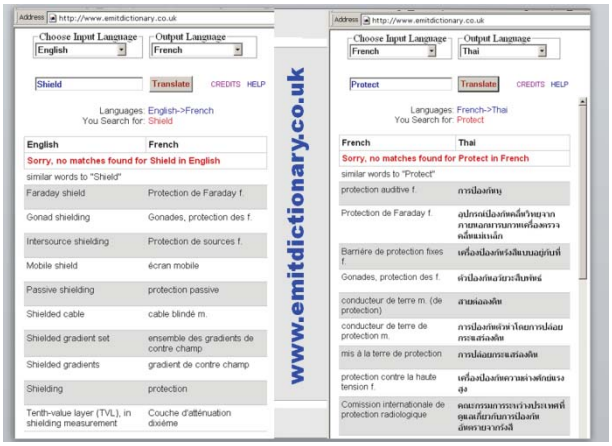

Figure 2. Screen shot of the first web design of the Dictionary

This Web Dictionary was using the users' Internet browser settings, hence it was working with various alphabets, as per the settings. This led to rapid expansion of the number of languages in the Dictionary.

The new web design included own search engine, what allowed direct search for terms, or part of terms, this way reducing the problems with possible misspelling.

The design again used a user-friendly interface with windows for Input and Output Languages and a small Search window for the term to be translated. The results were displayed as two parallel tables of corresponding terms (scrollable).

The new Web Dictionary was launched in 2005 and for several months attracted thousands of users. This led to further increase of the number of languages. This expanded use required a dedicated Coordinator to be used for providing link between the Groups of professionals translating the terms. A number of societies realised at this stage that no specific translation exists for some terms in their own language. The rapid development of the profession, often triggered by quick publications in English

had left some terms without sufficient coverage in the respective language. This triggered creation of national terms and respectively some changes in the Dictionary translations (all handled by the Coordinator and AM Studio).

V. EMITEL ENCYLOPAEDIA WITH DICTIONARY

The initial idea of a Dictionary of terms with explanations was developed in a new project EMITEL, which aimed at developing explanatory articles for each term (and at the same time expanding the number of languages in the Dictionary) [7]. This project was approved by the EU Leonardo programme during 2006 and was announced during the 2006 World Congress of Medical Physics and Biomedical Engineering in Seoul, South Korea [8]. While the previous EMIT project included as a partner the European Federation of the Organisations for Medical Physics (EFOMP), the new project EMITEL included as partner the International Organisation for Medical Physics (IOMP). These were the first large projects for both institutions, allowing them future inclusion and initiation of new projects and attracting respective funding.

A new web site was developed for EMITEL (www.emitel2.eu), handling both the Dictionary and the future Encyclopaedia [9]. New design was introduced (again by AM Studio, now a full partner to the project). It included a new web database, but still was using the initial parallel language tables, which proved very useful. Two Search Engines were designed – one of those being Multilingual (handling the Dictionary), the other one – in English, only for the Encyclopaedic entries (Figure 3) [10].

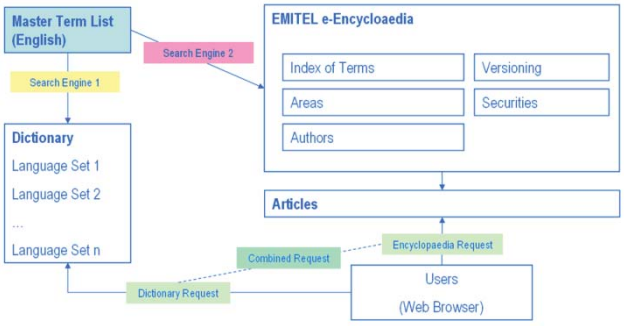

Figure 3. Diagram of the information flow of the EMITEL web site, including both the Encyclopaedia and Dictionary

During the process of this development the Thesaurus was updated due to the evolution of the profession in the past decade. To handle this the IDs of the existing terms were left 'as is' and a new continuation of the main English master file was made starting with ID 4000 (again including all new terms in alphabetical order from 4001 onwards). New 756 terms were added this way. However the existing terms (from the beginning of the project) were reduced with 990, excluding some terms which could be explained through other terms (and hence listed as similar to synonyms). Following this the overall number of terms in the Encyclopaedia was 3576. These final terms of the updated Thesaurus were explained in the Encyclopaedia with respective articles (and displayed in the Dictionary at www.emitel2.eu).

During the paper print of the Encyclopaedia (2010-12) the number of terms covered with articles was further reduced (mainly through merging of terms and excluding abbreviations), but the above number is still used on the web site.

VI. DICTIONARY USE AND CONCLUSION

Despite the fact that the Encyclopaedia web site www.emitel2.eu includes the Dictionary (used by many professionals), the old web site www.emitdictionary.co.uk is still alive and currently has some 1200 users per month. During the 3 months (April – June 2013) 4619 colleagues have used the old web site (Figure 4), while the new web site, including the Encyclopaedia and Dictionary, has been used by 10,174 colleagues.

Currently the Dictionary exists in 29 languages, translated by colleagues listed at the end of this paper. Thus the original 7 languages English, Swedish, Italian, French, German, Portuguese, Spanish, were supplemented by new 22 languages (as per their inclusion): Bulgarian, Czech, Estonian, Greek, Hungarian, Latvian, Lithuanian, Polish, Romanian, Slovenian, Bengal, Chinese, Croatian, Iranian, Arabic, Malaysian, Russian, Thai, Turkish, Japanese, Finnish and most recently Korean.

Figure 4. Statistics of web Dictionary use in the period Apr-June 2013 (for www.emitdictionary.co.uk)

Today, 10 years since its first introduction the Dictionary of Medical Physics Terms continues to be one of the most important references of the profession. Thousands of colleagues use it every month. The constant assessment and update of the Dictionary through the bi-annual College of Medical Physics in ICTP, Trieste (including colleagues from c. 30 countries in each College) keeps the Dictionary up-to date and in line with the development of the profession.

The first Thesaurus of Medical Physics Terms provided background for other Dictionaries and will be the starting

point of a number of new projects for the international expansion of the profession.

One very important outcome of the project was that it collated for the first time in the profession a team of over 200 specialists from 29 countries. These included senior officers of IOMP, EFOMP, AFOMP, ALFIM and Past and Present Presidents of 21 National Medical Physics Societies. ACKNOWLEDGEMENTS

EMITEL gratefully acknowledges the volunteering translation of the Dictionary made by the following Contributors (included in the EMITEL Network together with the Contributors to the Encyclopaedia):

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VII. ANNEX: "HOW TO USE THE WEB DICTIONARY"

To use the Dictionary at WWW.EMITEL2.EU >> select *Dictionary* >> choose the Input and Output languages >> write the term you want to see at the window >> click Search. A list with terms is displayed, where the terms are found either as single word, or in combination with other words (the e-Dictionary assumes that the user's Internet

browser already supports the Languages). Terms without existing translation are in English.

To use the Encyclopaedic articles titles (quick search in English) >> select *Encyclopaedia* plus *Title* combo >> write the term you want to see in the window >> click Search. A list with terms is displayed – against each one is a blue hyperlink related to the area of the term >> click the hyperlink to read the article. This search covers only the titles of the articles. Some articles have two entries (related to two categories – e.g. Magnetic Resonance and Ultrasound) – in this case select the necessary cathegory.

To search for a specific word/title within the text of the entires the user has to select *Encyclopaedia* plus *Search in Full Text* combo >> specify the category/area of the search (e.g. Radiotherapy) and proceed as above. In case of UK or American/English differences try both spellings or search only part of the term.

To use both the Encyclopaedia + Dictionary >> select *Combined* and proceed as above (this search is limited only to the title of the article, not inside its text). The text and images of the articles allow copy/paste in another file (N.B. formula-related text is presented as image).

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PRACTICAL AND APPLIED MEDICAL PHYSICS

A SIMPLIFIED TOOL FOR CALCULATING SIZE-SPECIFIC DOSE ESTIMATES FOR COMPUTED TOMOGRAPHY

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Abstract—**With growing concern over radiation from computed tomography (CT), there is an increasing need to monitor dose. Dose information provided by CT scanners is based on phantom measurements and does not take into account patient size.**

The American Association of Physicists in Medicine (AAPM) Report #204 addresses the effect of patient size on CT dose, providing tools for calculation of size-specific dose estimates (SSDE) based on the computed tomography dose index (CTDI) and patient size. While the methodology in the AAPM Report is not technically difficult, it is not user-friendly. We developed a web-based calculator allowing users to enter key input values and display SSDE.

Keywords— **Radiation, Dose, Computed Tomography**

I. Introduction

There is growing public concern over radiation from computed tomography (CT) examinations, both because of radiation accidents reported in the media as well as widely publicized future cancer predictions in medical journals. This concern is reflected in an increasing demand to monitor CT dose. However, defining CT dose can be complicated. CT scanners routinely provide dose index (CTDI) and dose length product (DLP) in a dose report generated at the end of each study. Scanners also display an estimate of the CTDI before exposure when an imaging protocol is selected. This pre-scan estimate, however, may not take into account dose-reduction techniques such as automatic exposure control implemented during the study.

Values of CTDI and DLP reported by the scanner are based on measurements previously made in a standard phantom and do not take into account patient size. A given CT beam and setup can result in a large variation in patient dose depending on the size of the patient. Most technologists and radiologists are aware of this, which is one reason we use different techniques for pediatric than for adult patients. It is also the reason modern CT scanners incorporate dose reduction technologies such as automatic exposure control where tube current (mA) is modulated as the x-ray tube rotates around the patient and the patient moves through the bore of the scanner.

While we may take patient size into consideration in the performance of an examination, the dose values reported by the scanner ignore it. These reported values reflect what a medical physicist would measure in a uniform cylindrical Lucite phantom. These phantoms come in two standard sizes, with diameters of either 16 or 32 cm. The dose report generated by the scanner provides both CTDI and DLP as well as the phantom size to which it applies. However, a given study resulting in a particular reported CTDI would give a different dose to a smaller patient than to a larger one. So monitoring of the reported CTDI does not provide an accurate estimate of the dose received by the patient, since patient size is not addressed in the calculation of this value.

AAPM Report #204, "Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations", addresses the failure of CTDI to take patient size into account. Citing research performed with phantoms of various sizes, this report provides a framework for correcting CTDI for the size of the patient. This report has several ways for a user to specify the size of a patient. Actual measurements of either AP or lateral patient dimension, or both, can be used. These can be derived before an examination using manual measurements, or by measuring from the scout exam before axial images are obtained. Or measurements can be made after the examination from axial images. Although obviously less accurate, the AAPM report also allows size to be estimated using patient age (for pediatric patients).

The AAPM report provides methods that can be used to allow physicians or technologists to calculate size-specific dose estimates (SSDE) based on the CTDI. This calculation can be done either before the CT exam using the estimated CTDI provided by the scanner after exam protocol selection or from the CTDI provided on the dose report after the examination. The method for calculating SSDE from CTDI described in the AAPM report requires several manual steps. The user must navigate through various tables to find a dose conversion factor and then perform a manual

calculation to determine SSDE. While the process is not technically difficult, it requires multiple steps and is not user-friendly. To simplify this process at the Georgia Regents Health Center, we developed a web-based tool that allows a user to enter the key input values and obtain the calculated SSDE.

II. Methods

AAPM Report #204, published in 2011, describes a methodology for estimating patient dose from the $CTDI_{VOL}$ reported by the scanner and information about patient size. Patient size is quantified in the report using a parameter called the "effective diameter" whose area is equal to that of the cross section of the patient. Using the assumption that the patient is elliptical in cross section, the AAPM report provides formulas and tables which allow the determination of the effective diameter using either the AP or lateral dimension of the patient individually, or both if known. Using this effective diameter, the report provides formulas and tables to arrive at a conversion factor, which is then multiplied by the scanner-reported $CTDI_{VOL}$ to arrive at the size-specific dose estimate. The report contains two sets of conversion factor tables, one for the 16 cm phantom and one for the 32 cm phantom.

In the report's introduction, it states that radiologists and technologists need user-friendly computational tools to estimate radiation dose during CT examinations. While the methodology described in the report is not difficult, it fails to be user-friendly. First the user must go to the appropriate table (16 or 32 cm phantom), find the appropriate sub-table depending on whether both the AP and lateral patient dimensions are known or only one, locate the conversion factor on the table, and then multiply this conversion factor from the $CTDI_{VOL}$ reported on the scanner. Alternately, if patient dimensions are not known, there is a separate table that allows one to obtain the effective diameter from the patient's age. Using this effective diameter, the user returns to the appropriate sub-table previously described to find the conversion factor that must be multiplied by the scanner-reported $CTDI_{VOL}$ to get the SSDE.

We have developed an easy-to-use web-based tool that performs all the look-ups and calculations (Fig. 1). The user first enters the scanner-reported $CTDI_{VOL}$ and associated phantom diameter, plus either the patient dimension(s) or age. The user can then enter either the AP dimension or the lateral dimension, or both. The page also contains background information and instructions. Once the patient dimension(s) and CTDI data are entered, the user clicks the "Calculate (dim)" button. The web site logic takes whatever is entered to determine how to implement the AAPM report methodology. The result is a simple report page showing the entered information and the calculated SSDE in the format specified in the AAPM report. If dimensions are not known, one can enter the scan date and the patient's date of birth and click on the "Calculate (age)" button. The program will calculate the patient's age and from the age calculate the SSDE.

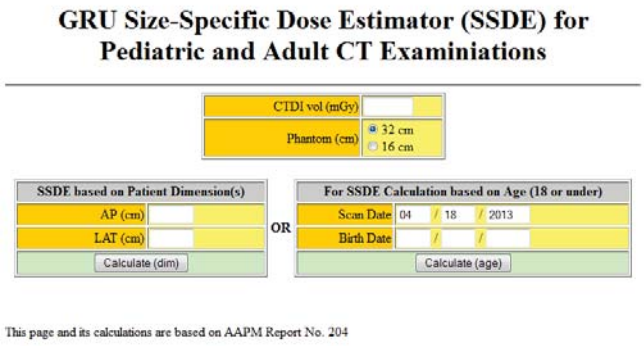

Fig. 1 SSDE Input Screen

III. Discussion

To be useful and used, a tool should be simple and straightforward. The web pages described here allow a user to very quickly enter the required information and generate the SSDE report. An additional benefit is that the report can be printed or saved, allowing it to be given to a patient or archived. The SSDE calculation page can be freely accessed at the following link: http://www.gdavidasp.net/gdavid/DoseCalculators/ssde.asp

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INNOVATIONS

ITERATIVE MODEL RECONSTRUCTION: SIMULTANEOUSLY LOWERED COMPUTED TOMOGRAPHY RADIATION DOSE AND IMPROVED IMAGE QUALITY

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Abstract— **Computed Tomography (CT) scanner technology has progressed rapidly throughout the past decade, with major advances in CT x-ray detection, system speed, and image reconstruction that have resulted in a still-increasing number of novel CT clinical applications. Concomitant to this increase in clinical applications, CT technology has also experienced innovation to support the realization of high CT image quality while adhering to the As Low As Reasonably Achievable (ALARA) principal of radiation dose management. Notable among these innovations are the introduction of modular detector designs that are optimized for low-energy, low-noise data acquisition (e.g., NanoPanel Elite, Philips Healthcare) and the introduction of innovative reconstruction techniques (e.g., iDose^4, Philips Healthcare) that improve image quality at low-dose, and exhibit reconstruction times that fit within traditional CT workflow.**

The evolution to knowledge-based iterative reconstruction algorithms that utilize additional system information to enable significant CT radiation dose reduction and image quality improvement is the next step in CT technology innovation. Although these more advanced algorithms have been used in single-photon-emission computed tomography and positron-emission tomography for some time, their use in CT was historically limited by long, clinically unacceptable, reconstruction times.

Recently, IMR (Iterative Model Reconstruction, Philips Healthcare), combined with new computational hardware, has demonstrated simultaneous significant improvements in image-quality and significantly lower dose with reconstruction times of less than 5 minutes for a majority of reference protocols. Phantom tests demonstrate that IMR may simultaneously enable 60% – 80% lower radiation dose, 43% – 80% low-contrast detectability improvement, and 70% – 83% less image noise, relative to filtered back projection. Alternatively, IMR may enable 1.2x – 1.7x high-contrast spatial-resolution improvement; or 2.5x – 3.6x low-contrast detectability improvement; or 73 - 90% image noise reduction, relative to filtered back projection.

This article provides a review of the algorithm and its performance characteristics based on phantom studies.

Keywords— **Iterative Reconstruction, Knowledge-based, Model-based, IMR**

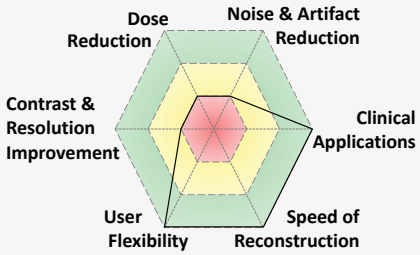
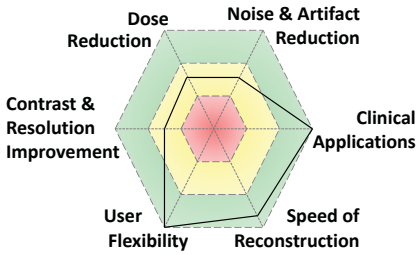
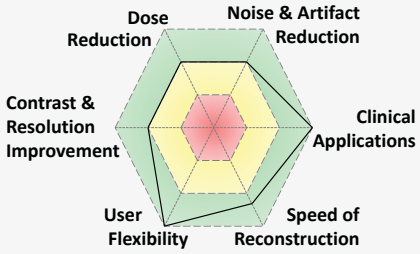
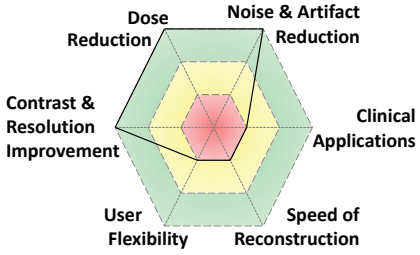
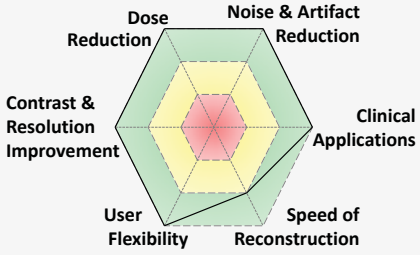
I. INTRODUCTION

During the last decade, technological advances have markedly enhanced and expanded the range of computed tomography (CT) clinical applications [1]. Consequently, physicians have ranked CT atop the list of innovations that have improved patient care. While the benefits of CT have been very well documented, increasing radiation doses to the population drew attention to the need for reducing radiation exposure from CT [2]. In response, the radiology community has worked to adhere to ALARA principles in CT imaging [3]. Working closely with the clinical community, dose management is simplified further with the advances in CT scanner technology [4]. Each stage of the imaging chain—from tube to detector—has been enhanced with innovative volume imaging technology and integrated with new dose management and reporting tools [5]. Novel reconstruction algorithms allow further opportunities to manage dose and improve image quality [6,7].

Filtered back projection (FBP) has been the industry standard for CT image reconstruction for decades. While it is a very fast and fairly robust method, FBP is a sub-optimal algorithm choice for poorly sampled data or for cases where noise overwhelms the image signal. Such situations may occur in low-dose or tube-power–limited acquisitions (e.g., scans of morbidly obese individuals). Over time, incremental enhancements were made to FBP to overcome some of its limitations. These improvements

continued until recently, when advances in computing performance made it possible to explore iterative reconstruction (IR), a completely different approach to image reconstruction. IR techniques, such as IMR (Iterative Model Reconstruction, Philips Healthcare) attempt to formulate image reconstruction as an *optimization* problem i.e., IR attempts to find the image that is the "best fit" to the acquired data, while penalizing the noise [7].

Table 1 Evolution of CT reconstruction

Reconstruction	Potential Benefits	Description
Filtered backprojection		FBP has been the preferred algorithm for CT image reconstruction since its inception. This preference was attributed primarily to the ability of FBP to practically reconstruct images given the available computing resources; however, the limitations of FBP reconstruction have become more apparent as dose levels have been pushed to new lows in the spirit of imaging as low as reasonably achievable (ALARA).
Image-based Denoising [8]		Incorporating denoising in the image domain, these techniques were developed to produce reduced noise images, helping manage dose[6]. However, inability to address artifacts associated with significantly reduced doses, and limited image quality benefits, are becoming more apparent. Due to the reduced computational requirements, these techniques may achieve the reconstruction speeds of FBP. Current applications are limited to providing scanner agnostic, cost-effective solution; but at the expense of limited benefits.
Statistical / Hybrid Iterative Reconstruction		Incorporating statistics-model based denoising into raw and image data space these techniques are replacing FBP as the standard of CT reconstruction [6,9,10,11]. With significant noise reduction and artifact prevention, these techniques work well in helping manage dose while maintaining the image quality. Alternatively, Image quality benefits may be achieved. Combining dose management, with image quality improvements simultaneously may be limited with these approaches.
Model-based Iterative Reconstruction		Solving the reconstruction as an optimization process that incorporates forward-models (that model system geometry) in addition to statistics-models, these solutions take image quality and dose management further [12]. However, the long reconstruction times, restrictions to non-gated applications, and limited user flexibility, limit the routine applicability of these solutions.
Knowledge-based Iterative Model Reconstruction		Based on optimization processes similar to those used in model-based iterative reconstruction, solutions such as IMR (Philips Healthcare) enable model-based benefits that can be achieved routinely [7]. Increased computational requirements result in reduced recon speeds compared to statistical/hybrid approaches. However, newer hardware platforms can be designed to provide clinically acceptable reconstruction times.

II. Evolution of iterative reconstruction

While different implementations of IR (image-based, statistical/hybrid-based, model-based, and knowledge-based) have been made commercially available by various vendors, their clinical value varies dramatically. There is continued debate in the scientific community with regard to the optimal implementation. Classification of reconstruction techniques based on their clinical results as well as objective phantom-based measurements provides a logical — and more meaningful — differentiation among these techniques. Also, the reconstruction times, flexibility and applicability to advanced modes such as ECG-gated scans, are other crucial components when evaluating the practical value of different IR implementations. The classification in this article is based on the value that reconstruction algorithms provide in terms of improving image quality, reducing radiation dose, and ease of integration into routine hospital workflow.

Knowledge-based iterative reconstruction algorithms such as IMR differ from FBP methods in that the reconstruction becomes an optimization process that takes into account the data statistics, image statistics, and system models[12]. These can be constrained optimization processes which still provide the user some amount of control over the desired image characteristics. Figure 1 gives a high-level overview of the IMR algorithm.

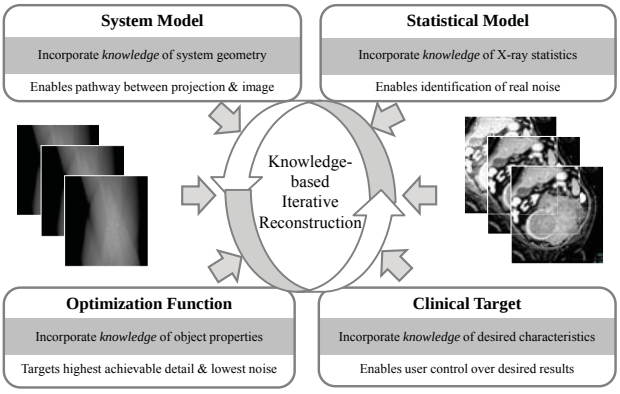


Fig. 1 IMR – Algorithm Overview

Very simplistically a cost function represents (a) the difference between an estimate of the data and the actual data that was acquired, and (b) a regularization term. Since, it can be expected that a noisy image will be a valid solution the difference between estimate and actual data, a constraint (regularization) is required. A constraint that enforces image smoothness would drive the optimization process to produce noise free data, and the level to which this is enforced can control the level of noise reduction. A smoothness constraint will take into account knowledge of the data statistic models. In other words, knowledge of the quantum noise statistics in the projection data could introduce bounds on the solution of the problem.

In addition, in the formulation of the cost function, there are known characteristics of the CT system that can additionally be used to target a desired resolution of the solution. For example, the achievable spatial resolution of the final image is driven by the detector sampling, angular sampling and system geometries. Spatial resolution can be maximized without the introduction of image artifacts by including this knowledge into the optimization process. Similar models for different system components and system physics can be introduced. Together, the careful consideration of the system properties allow for design of the cost function, allowing IMR to effectively control the image noise while maximizing spatial resolution at radiation doses that are significantly lower than those traditionally used with FBP reconstruction.

Algorithmic choices on a knowledge-based IR solution help overcome the motion sensitivity associated with traditional model-based solution, allowing for knowledge-based IR solutions to be used in advanced modes such as Cardiac CTA.

Furthermore, algorithmic optimizations of this knowledge-based solution combined with cutting edge reconstruction hardware leads to fast reconstruction times of less than 5 minutes for a majority of reference CT protocols, as can be seen in figure 2.

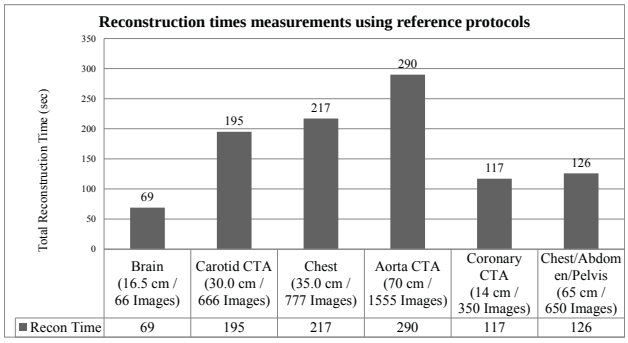


Fig. 2 Plots of IMR reconstruction time measurements for sub-set of reference protocols on a Philips Ingenuity Elite scanner.

III. Phantom testing

Image quality testing using standardized methods for objectively measuring noise, high contrast spatial resolution, CT number accuracy and CT number uniformity was conducted on phantoms to provide reproducible objective data. The parameters for testing were selected to provide denoising effects expected to be

appropriate for different clinical tasks. Additionally, tests for evaluating the performance of IMR with respect to dose reduction, and low contrast detectability (LCD) were conducted using test methods emerging in the industry as standardized approaches for such assessments.

Descriptions of the image quality metrics, phantom-based tests utilized for the IMR evaluation and their results are discussed in this section.

A. Image Noise

Image noise is a measure of statistical fluctuations in the image. It is a consequence of a variety of statistical processes that occur in the detection of x-rays by a CT system, but the dominant source is the quantum fluctuations in x-rays. An x-ray tube will not emit an exact number of x-rays over a given time period, but rather the number of x-rays will fluctuate around a mean value according to a Poisson distribution. After attenuation through the patient and detection at the detector, which are governed by further statistical processes, the measured data will contain noise which gets transferred into the image during reconstruction. Noise is measured by calculating the standard deviation of pixels in an region-of-interest (ROI) of a uniform section of a phantom.

A water phantom (water equivalent diameter = 30 cm) and the technique standardized in IEC61223-3-5 section 5.5 were utilized for the testing. To characterize the noise performance across the typical dose range used clinically, multiple acquisitions were performed to cover a range of 50 – 500 mAs, in 50 mAs increments. All other acquisition parameters were held constant at 64 x 0.625 collimation, 120kVp, 512 x 512 matrix and standard resolution. Thin-slices of 1.0 mm thickness were reconstructed using FBP (Filter B), iDose^4 (Filter B, Level 4 = mid-level & Level 6 = high-level) and IMR. IMR reconstructions were targeted for low-contrast visualization ("Image definition" = soft tissue, "noise reduction" = Level 3). Standard deviation of pixels was measured using a circular ROI with area 5000±200 mm^2, for the different reconstructions and dose levels, at the same phantom location. Results showed that noise reduction of up to 90 % was achieved with IMR, relative to FBP. Additionally, the noise performance stayed fairly constant, less than 10 HU, across the dose range tested. Figure 3 shows the noise versus dose measurements using the three reconstruction techniques.

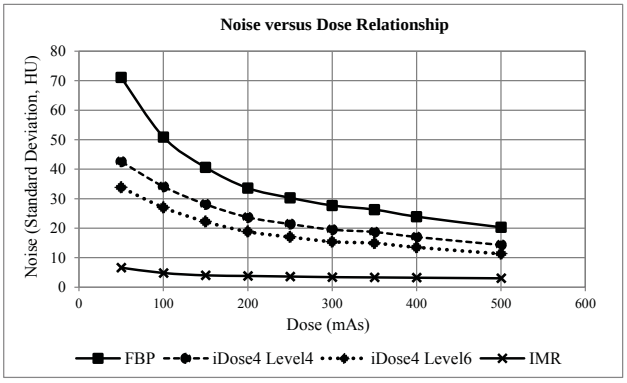


Fig. 3 Phantom images of same acquisition reconstructed using FBP (left) and IMR (right). Images demonstrate a 90.2% reduction in noise.

B. CT Number Accuracy

CT number accuracy is the ability of a CT system to accurately represent the CT number, expressed in Hounsfield Units (HU), in an image. The multi-pin layer of the Brilliance system phantom was utilized for the testing. The multi-pin layer contains pins of various materials (Teflon, Lexan, Acrylic, Teflon), within a water background. Acquisitions were performed across head & body protocols, and reconstructed using FBP (Filter B) and IMR. Measurements of the CT number (HU) was performed using a circular ROI, covering ¾th of the pin diameter. Results showed that when reconstructing the same data set with FBP and IMR, the CT number accuracy was maintained between reconstruction types. Table 2 summarizes the measurements.

Table 2 CT Number (HU) accuracy measurements

Object	FBP CT Number (HU) ± Noise (HU)	IMR CT Number (HU) ± Noise (HU)
Water	2 ± 14	2 ± 2
Polyethylene	51 ± 12	53 ± 2
Lexan	109 ± 12	111 ± 2
Acrylic	137 ± 11	137 ± 2
Teflon	916 ± 16	917 ± 5

C. High-contrast Spatial Resolution

High contrast spatial resolution is a measure of an imaging system's ability to preserve the spatial information in a high contrast object and accurately represent it in the image. It is expressed in terms of the modulation transfer function (MTF). Many factors influence the high contrast spatial resolution, including the design of the x-ray tube and detector, as well as the reconstruction algorithm. Traditional trade-offs between noise and spatial resolution in computed tomography exists via the reconstruction filter. In FBP, sharper filters can be used to produce images with high resolution, but

at the penalty of increased noise and reduced low-contrast. With IMR, high contrast spatial resolution is improved while simultaneously reducing noise.

The high contrast MTF was measured using a standardized technique (IEC61223-3-5: 5.6) on a CatPhan® 600 phantom, module CTP591 using the 50 micron tungsten wire. Acquisitions were performed at routine dose of 20.0 mGy, and low dose of 4.0 mGy. Additionally, high-res (small focal spot) acquisitions with similar dose parameters were performed. All other acquisition parameters (collimation, kVp, etc.) were held constant. Thin-slices of 1.00 mm thickness were reconstructed using FBP (Filter B), and IMR. IMR reconstructions were targeted for high-contrast (Image definition = Sharp, noise reduction = Level 3). The $MTF_{50\%}$ and image noise were measured.

Results showed 1.2x to 1.7x improvement in high-contrast resolution with 43% less image noise, simultaneously. The lower-bound captures the improvement when using IMR and low-dose (4 mGy), and the upper-bound when using IMR at routine-dose (20 mGy) when combined with the high-resolution acquisition mode. Figure 4 captures the noise and spatial resolution improvements.

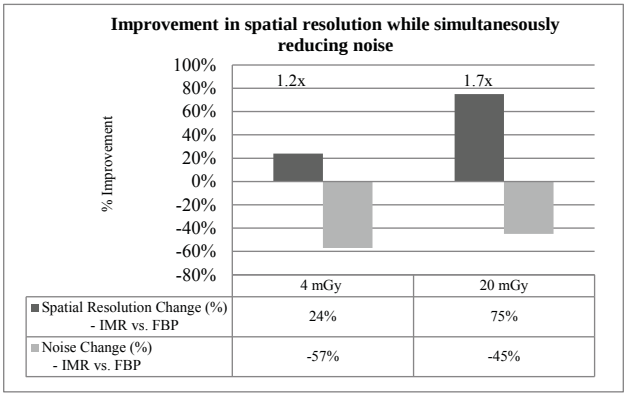


Fig. 4 Plots of image noise and high contrast spatial resolution improvements (%) with IMR, relative to FBP, at 4 mGy (left) and 20 mGy (right). Results demonstrate 1.2x to 1.7x improvement in spatial resolution, with noise reduction, simultaneously.

D. Low-contrast Detectability

The image quality metrics discussed thus far are properties of the imaging system alone. They represent the degree to which a CT scanner generates images which accurately represent various aspects of what is in the scanned object. Physical measurements, and mathematical analysis of those measurements, characterize image quality independently from how it might be perceived by a person looking at the image. Low contrast detectability (LCD), on the other hand, is a measure of a person's ability to perform a particular task: the detection of a low contrast object. LCD is influenced to some degree by all of the image quality metrics discussed above, as well as the reaction of the human visual perception system to those factors. High noise may obscure the low contrast object in the noise and make it difficult for a human to perceive it. Poor spatial resolution may blur the object and blend it in with the background and poor uniformity or CT number accuracy may confound a person's ability to visualize a low contrast object. Due to the influence of noise, and the fact that the exact appearance of noise changes from one scan to the next, accurately capturing the influence of noise on LCD requires a statistical approach. In other words, LCD cannot be assessed from a single image, but rather an ensemble of images must be used to characterize the average performance. To assess the impact of IMR on low contrast detectability, it was measured by a method known as a human observer study. This is a new phantom and bench testing methodology that the industry is moving towards for assessing LCD [14]. In this method, a cohort of human test subjects is asked to perform a low contrast detectability task on a set of repeated scans of a phantom. The particular method employed is known as an alternative forced choice human observer test [15]. From the average ratio of correct responses, a quantity known as the detectability index can be calculated. The detectability index is a dimensionless quantity that characterizes the degree to which subjects can distinguish images with the low contrast object present from those with it absent. The detectability index ranges from 0, where subjects have no ability to distinguish the low contrast object, to higher values representing improvement in low contrast detectability. An alternative forced choice human observer study was used to show that IMR reduces noise in images without degrading low contrast detectability. The phantom used is a custom made low contrast phantom from the Phantom Laboratories. It is 20 cm in diameter, consisting of a Catphan-like shell, and a background plastic with CT number of approximately 45 HU at 120 kVp. It contains four low contrast pins with diameters of 3, 5, 7, and 10 mm and contrast levels of +14, +,7 +5 and , and +3HU respectively. Each pin is 20 mm long, and all four pins are located in the same z-position of the phantom. A significant improvement in LCD was measured for IMR compared to FBP. This can be seen with the following two types of scans:

Acquisitions were performed using 10 mGy to assess improvements at routine dose, and 4 mGy to assess improvements at low dose. All other acquisition parameters (collimation, kVp, etc.) were held constant. Reconstructions were performed using FBP (Filter B, and Filter C) and IMR. To assess performance characteristics across the IMR settings, reconstructions were performed using both low-contrast visualization, and high-contrast visualization, settings. Assessments in LCD were

performed by 36-observers, based on 200 image datasets each, using the human-observer method described above.

Results showed 2.5x to 3.6x improvement in low-contrast detectability. The lower bound captures the improvement with IMR at routine-dose and high-resolution optimized settings, and the upper-bound when using IMR at low-dose with low-contrast optimized settings. Figure 5 summarizes the IMR LCD results.

Fig. 5 Plots of LCD assessments using FBP & IMR, at 4 mGy (left) and 10 mGy (right). Results demonstrate 2.5x improvement in LCD at routine-dose of 10 mGy and 3.6x at low-dose of 4 mGy

E. Dose Reduction

Low-contrast detectability assessments similar to the methodology previously discussed were performed to assess the dose reduction capability of IMR. Multiple 120 kVp acquisitions were performed using 10 mGy, 4 mGy, and 2 mGy dose. Reconstruction of the routine-dose (10 mGy) was performed using FBP (Filter B), and the low-dose was performed using IMR. To assess performance characteristics across the IMR settings, reconstructions were performed using both low-contrast visualization, and high-contrast visualization, settings. All other reconstruction parameters were held constant (0.8 mm slice thickness, 512 matix). Assessments in LCD were performed by 36-observers, based on 200 image datasets each, using the human-observer method previously described.

Results showed that with low-contrast optimized settings IMR could achieve 80% lower radiation dose with an 80% improvement in low contrast detectability and 70% less image noise. This was achieved when using the low-contrast optimized settings of IMR. When the settings were optimized for high-contrast, IMR could achieve 60% lower radiation dose with a 43% improvement in low contrast detectability and 83% less image noise. Figure 6 summarizes the results.

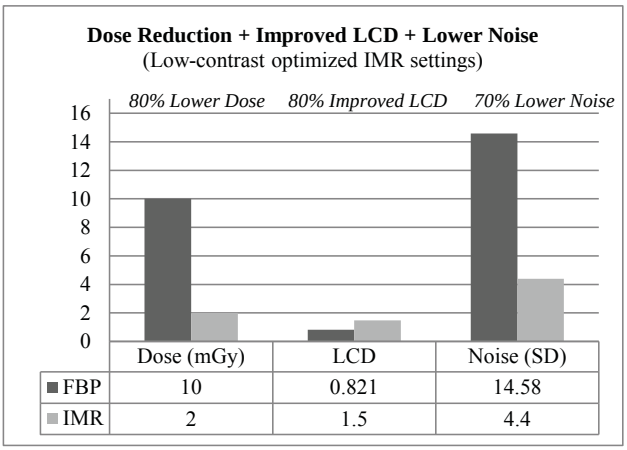


Fig. 6 Dose reduction assessments using human-observer studies, demonstrating 80% lower dose, with 80% lower LCD, with 70% lower noise.

F. Low Contrast Resolution

Low contrast resolution is a measure of the ability to distinguish a low contrast object from its background. Low contrast resolution is measured with a CatPhan® 600 module CTP515, with a viewing setting (window level & width) close to the CT number values of the low contrast pins. Low contrast resolution is usually expressed as the smallest visible pin at a specific contrast level, at the scanned $CTDI_{vol}$.

Acquisitions of the phantom were performed at 120 kVp, 10.4 mGy $CTDI_{vol}$,. Repeated assessment by multiple readers on 7 mm slices showed the median visualization of the 2 mm pins with 0.3 % contrast. Figure 7 demonstrates a sample image from the IMR LCD results.

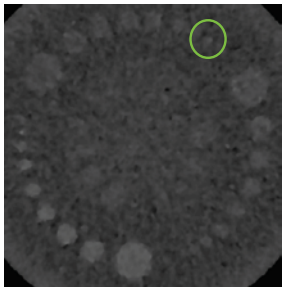
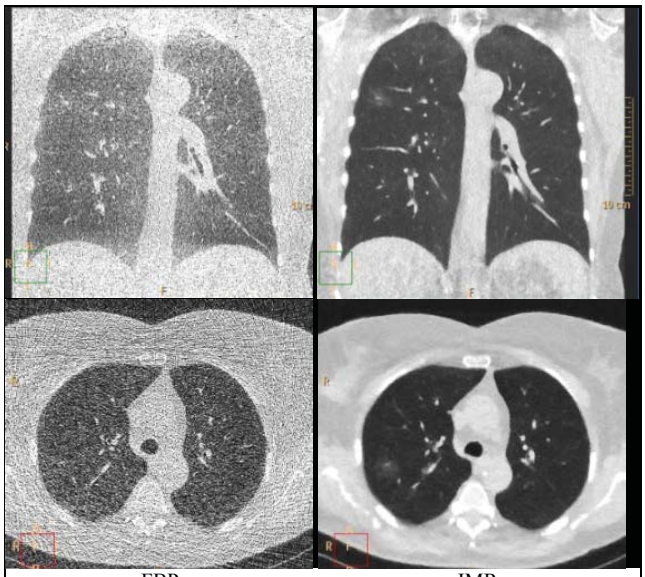


Fig. 7 Low contrast resolution of 2 mm contrast pin, at 0.3% contrast at 10.4 mGy $CTDI_{vol}$

IV. Clinical Examples

The clinical studies in figures 8-13 provide representative examples of the expected image quality and dose reduction capabilities that may be achieved with IMR. These are based on ongoing investigations at multiple clinical sites. In clinical practice, the use of IMR may reduce CT patient dose depending on the clinical task, patient size, anatomical location, and clinical practice. A consultation with a radiologist and a physicist should be made to determine the appropriate dose to obtain diagnostic image quality for the particular clinical task.

Chest CT at nearly the dose of chest x-ray

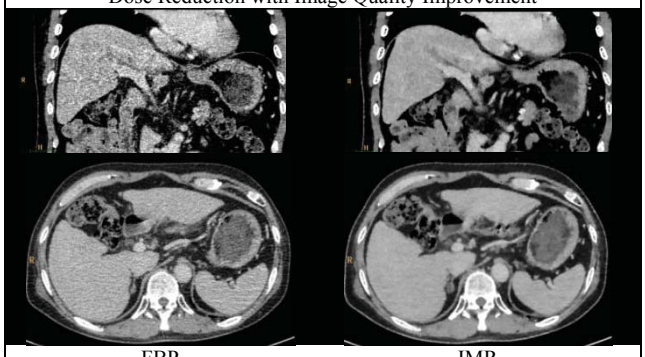


FBP IMR

80 kVp, 10 mAs, 0.2 mGy, 8.2 mGy x cm, 0.11 mSv (k = 0.014)

Fig. 8 A Chest scanned on a Philips iCT at 0.11mSv (80 kVp, 10 mAs, 0.2 mGy, 8.2 mGy x cm) and reconstructed using FBP (left) and IMR (right). Study shows limited visualization of the Ground Glass Opacity on the FBP reconstructions. IMR significantly reduces noise and artifacts, revealing structural information. Courtesy of Cliniques Universitaires St-Luc, Brussels, Belgium.

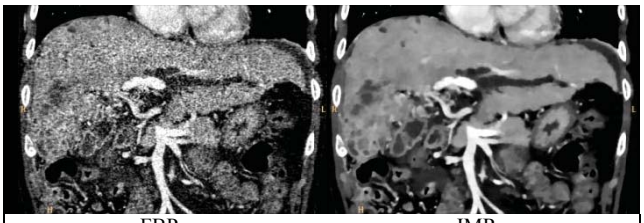
Dose Reduction with Image Quality Improvement



FBP	IMR
Routine-dose scan	Low-dose scan
4.2 mSv	1.6 mSv
120 kVp, 249 mAs, 14.6 mGy, 277.4 mGy x cm, 4.2 mSv (k = 0.015)	120 kVp, 93 mAs, 5.5 mGy, 104.5 mGy x cm, 1.6 mSv (k = 0.015)

Fig. 9 An abdomen scanned on a Philips iCT at routine-dose of 4.2mSv (120 kVp, 249 mAs, 14.6 mGy, 277.4 mGy x cm) reconstructed with FBP (left), and the low-dose exam at 1.6mSv (120 kVp, 93 mAs, 5.5 mGy, 104.5 mGy x cm) reconstructed with IMR (right). IMR allows lower dose with improved image quality, simultaneously. Courtesy of Guangdong General Hospital, China.

Improved Low-contrast detectability

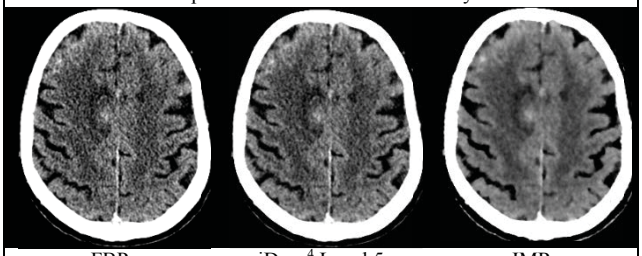


FBP IMR

80 kVp, 500 mAs, 9.8 mGy, 170.5 mGy×cm, 2.5 mSv (k=0.015)

Fig. 10 An Abdomen scanned on a Philips iCT at 2.5mSv (80 kVp, 500 mAs, 9.8 mGy, 170.5 mGy×cm) and reconstructed using FBP (left) and IMR (right). Study shows limited visualization of lesions on the FBP reconstructions. IMR improves the low-contrast detectability. Courtesy of Guangdong General Hospital, China.

Improved low-contrast detectability

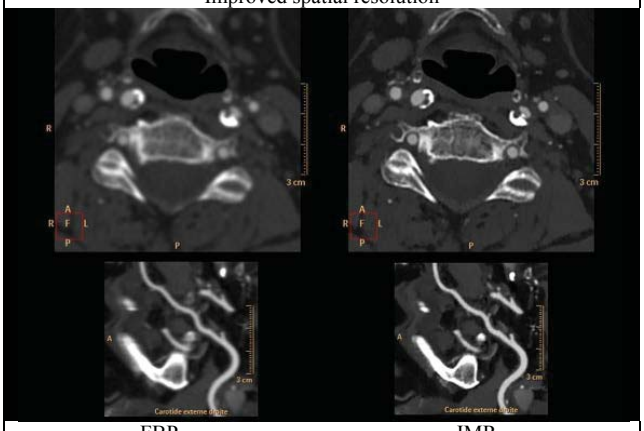


FBP	iDose^4 Level 5	IMR
3 mm slice thickness	3 mm slice thickness	1 mm slice thickness

120 kVp, 300 mAs, 14.3 mGy, 1.8 mSv (k=0.0021)

Fig. 11 A brain scanned on a Philips iCT at 1.8 mSv (120 kVp, 300 mAs, 14.3 mGy) reconstructed with FBP at 3mm slice thickness (left), iDose^4 at 3 mm slice thickness (center), and IMR at 1 mm slice thickness (right). Study shows limited visualization of haemorrhagic lesions on FBP. IMR improves low contrast detectability. Courtesy of Cliniques Universitaires St-Luc, Brussels, Belgium.

Improved spatial resolution



FBP IMR

100 kVp, 200 mAs, 8.8 mGy, 35.1 mGy×cm, 0.7 mSv (k=0.0021)

Fig. 12 A carotid CT angiogram on a Philips iCT at 0.7mSv (100 kVp, 200 mAs, 8.8 mGy, 35.1 mGy×cm), reconstructed using FBP (left) and IMR (right). Study shows limited resolution on FBP, at a given noise target. IMR significantly improves spatial resolution, and at the same time lowers noise. Courtesy of UCL, Belgium.

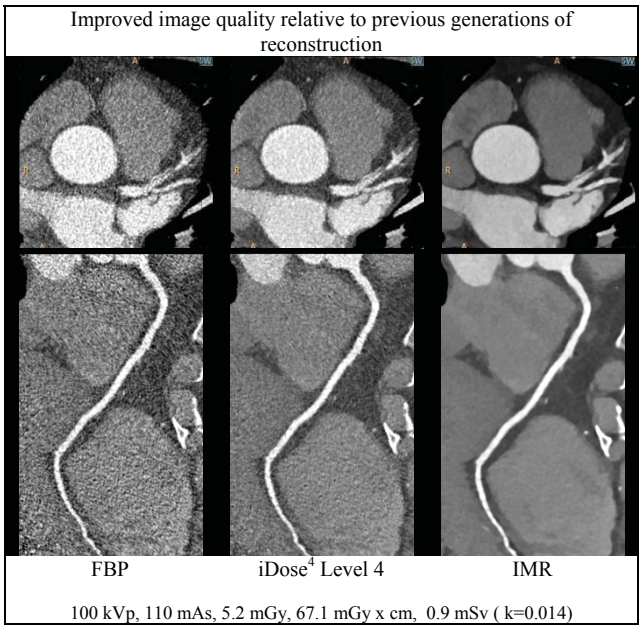


Fig. 13 An ECG-gated coronary CT angiogram scanned on a Philips iCT at 0.9 mSv (100 kVp, 110 mAs, 5.2 mGy, 67.1 mGy x cm) and reconstruction with FBP (left), iDose^4 center, and IMR(right). Study shows limited visualization of soft-plaque on FBP. IMR improves spatial resolution, low-contrast, and noise characteristics. Courtesy of Amakusa Medical Center, Japan.

V. Conclusion

Phantom tests demonstrate that IMR may simultaneously enable 60% – 80% lower radiation dose, with 43% – 80% low-contrast detectability improvement, and with 70% – 83% less image noise, simultaneously; relative to filtered backprojection. Alternatively, IMR may enable 1.2x – 1.7x high-contrast spatial-resolution improvement; or 2.5x – 3.6x low-contrast detectability improvement; or 73 - 90% image noise reduction, relative to filtered backprojection. This is a major leap from capabilities of hybrid/statistical iterative reconstruction approaches.

Reconstruction speeds of less than 5 minute for a majority of the reference protocols, and applicability to non-gated and gated acquisitions, enables routine clinical use of IMR across a broad range of patients.

IMR is a paradigm shift in CT image quality. It emboldens a vision of expanding MDCT use, fueled by increasing clinical benefits and decreasing doses. This vision shows the way to provide information to increase diagnostic confidence and improve patient care.

Acknowledgment

We would like to thank our collaborators for sharing their clinical insights and the images demonstrating the benefits of IMR: Universitaires St-Luc (Belgium), Amakusa Medical Center (Japan), Guangdong General Hospital (China). Also, we would like to thank our colleagues Mark Olszewski and Ekta Dharaiya, for their valuable inputs and feedback on the manuscript.

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ANNOUNCEMENTS

ICTP: A MEDICAL PHYSICS TRAINING OPPORTUNITY FOR YOUNG PHYSICISTS FROM DEVELOPING COUNTRIES

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Abstract— **The Abdus Salam International Centre for Theoretical Physics (ICTP, Trieste, Italy) has announced a ICTP and Trieste University Master in Medical Physics, a two-years training programme in Medical Physics addressed to young physicists and mainly from developing countries. The initiative will be supported by IOMP, IAEA and TWAS (Academy of Sciences for the Developing World).**

Keywords— **Medical Physics Education, Master**

I. INTRODUCTION

The Abdus Salam International Centre for Theoretical Physics (ICTP, Trieste, Italy) has announced a ICTP and Trieste University Master in Medical Physics (MPMICTP), a two-years training programme in Medical Physics, co-sponsored by the Academy of Sciences for the Developing World (TWAS). The first course will be held during the period 1 January 2014 – 31 December 2015 and will lead to the Master Degree in Medical Physics. The Master Programme is designated to provide young promising graduates in physics or equivalent, mainly from developing countries, with a post-graduated theoretical and clinical training suitable to be recognised as Clinical Medical Physicist in their countries.

The ICTP, a UNESCO educational institution with training initiatives in the area of medical physics like the well known bi-annual College in Medical Physics and several ICTP/IAEA training courses, has developed the Master programme according to the recommendations of IOMP and IAEA for the education and the clinical training. IOMP and IAEA are seeing this initiative as an answer to the growing demand of Medical Physicists in developing Countries and are assuring important scientific and financial support.

The first year will be spent in Trieste, Italy, while the second year dedicated to the clinical professional training will be spent in a Medical Physics Department of a hospital of the training network.

The Master Programme in Medical Physics consists of basic and advanced courses and practical and clinical training given by experts in these fields. In the first year 330 hours of lectures and 230 hours of guided exercises are devoted to: Anatomy and Physiology as applied to Medical Physics, Radiobiology, Radiation Physics, Radiation Dosimetry, Physics of Nuclear Medicine, Medical Physics Imaging fundamentals, Physics of diagnostic and Interventional Radiology (X rays, US, MRI, Hybrid systems), Physics of Radiation Oncology, Radiation Protection, Information Technology in Medical Physics. There will be an examination at the end of each course.

The second year will be spent in a medical physics department of the hospitals' network for a full time clinical training in radiotherapy, diagnostic and interventional radiology, nuclear medicine and radiation protection. The first year practical and the clinical training will be informed by the IAEA recommendations (TCS37, TCS47 and TCS50)

After all courses, the practical and clinical training participants are required to work on a dissertation to be submitted and defended during the last month of the programme.

The Master will be awarded by the Trieste University only to those candidates who successfully complete all examinations, the clinical training and other requirements as may be decided upon by the Master Committee. Participants may also be required to take part in the ongoing activities of the ICTP in their related fields.

The Master Programme is open to young (generally below 30 years of age) qualified graduated from all countries that are members of the United Nations, UNESCO or IAEA. The maximum number of students admitted is 15 and the minimum qualification for applicants is a degree

equivalent to an M.Sc. in Physics or related fields. A limited number of full scholarships will be awarded to successful candidates from developing countries. A limited number of qualified candidates may attend the course at their own cost. Information and application form can be found at the master course website: www.ictp.it/programmes/mmp.aspx

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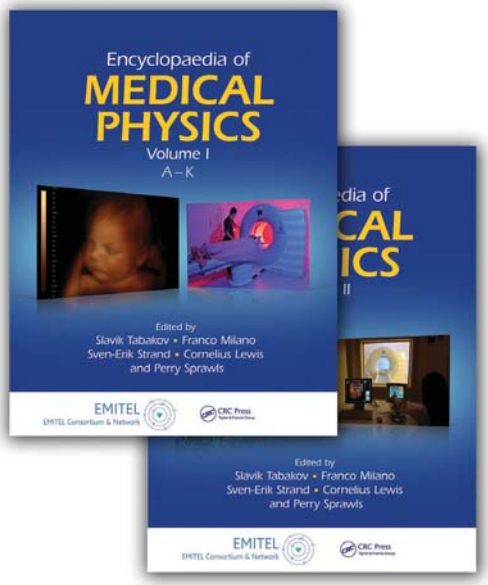

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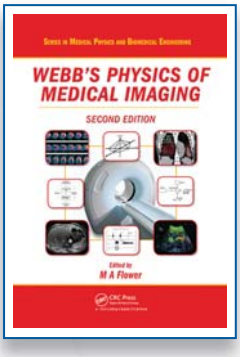

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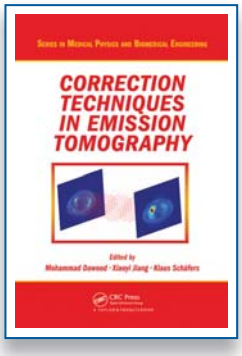

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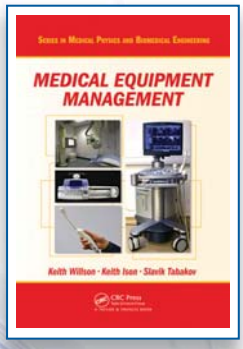

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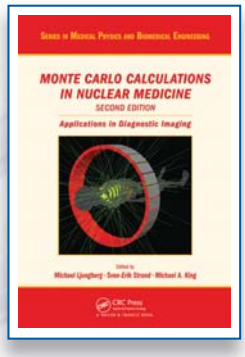

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PhD ABSTRACTS

STUDY OF DOSIMETRIC AND THERMAL PROPERTIES OF A NEWLY DEVELOPED THERMO-BRACHYTHERAPY SEED FOR TREATMENT OF SOLID TUMORS

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Studies on the curative effects of hyperthermia and radiation therapy on treatment of cancer show strong evidence of synergistic enhancement when both radiation and hyperthermia treatment modalities are applied simultaneously. A variety of tissue heating approaches developed to date still fail to overcome essential limitations such as inadequate temperature control, temperature non-uniformity, and prolonged time delay between hyperthermia and radiation treatments. We propose a new self-regulating Thermo-brachytherapy (TB) seed, which serves as a source of both radiation and heat for concurrent administration of brachytherapy and hyperthermia.

The proposed seed is based on the Best® Iodine-125 seed model 2301, where the tungsten marker core and the air gap are replaced with ferromagnetic material. The ferromagnetic core produces heat when subjected to an alternating electromagnetic (EM) field and effectively shuts off after reaching the Curie temperature (T_C) of the ferromagnetic material, thus establishing temperature self-regulation. The seed has a ferromagnetic Ni-Cu alloy core having a Curie transition at a temperature of 52 °C. This study summarizes the design and development of the self regulating ferromagnetic core TB seed for the concurrent hyperthermia and brachytherapy treatments. An experimental study of the magnetic properties of the $Ni_{1-x}Cu_x$ ($0.28 \leq x \leq 0.3$) alloys, and the simulation studies of radiation and thermal distribution properties of the seed have been performed. A preliminary experiment for the ferromagnetic induction heating of Ni-Cu needles has been carried out to ensure the practical feasibility of the induction heating.

Radiation dose characterizing parameters (dose rate constant and other TG-43 factors) were calculated using the Monte Carlo method. For the thermal characteristics, we studied a model consisting of single or multiple seeds placed in the central region of a cylindrical phantom using a finite-element analysis method, with and without considering the effect of the blood perfusion.

The experimental study of the Ni-Cu alloys shows that heat treatment has a strong influence on the magnetic properties of the Ni-Cu alloy. The Curie transition temperature, (T_C), of the $Ni_{1-x}Cu_x$ alloy decreases drastically with an increase in copper composition in the alloy. The study of the thermal expansion properties of the seed materials in the range of 37°C to 60°C shows negligible change in dimension due to the change of the temperature during the treatment. Imaging studies using CT and plane X-ray radiographs on the other hand, demonstrated that the new seed preserves the radiographic properties of the standard BEST seed model 2301 and is realistic for clinical use.

The modification of the internal structure of the seed slightly changes dose rate and other TG-43 factors characterizing radiation distribution. The thermal modeling results show that the temperature of the seed surface rises rapidly and stays constant around T_C of the ferromagnetic material. The amount of heat produced by the ferromagnetic core is sufficient to raise the temperature of the surrounding phantom to the therapeutic range. The volume of the

phantom reaching the therapeutic temperature range increases with the increase in frequency or magnetic field strength. An isothermal distribution closely matching the radiation isodose distribution can be achieved within a target volume by tuning the frequency and intensity of the alternating magnetic field. The effect of heat loss due to the blood perfusion in a living tissue can be compensated by adjusting the magnetic field parameter. The results of the preliminary induction heating experiment conducted in a ham slice (implanted with ferromagnetic needles) demonstrated practical feasibility of induction heating and thermal self regulating property of the ferromagnetic Ni-Cu alloy.

Modeling studies of the radiation and thermal properties of the TB seed show that the therapeutic implementation of the concurrent hyperthermia and brachytherapy treatment of the tumor is feasible. The seed has the capability of addressing some of the limitations of conventional hyperthermia treatment techniques, and has several advantages. The proposed seed model has high potential in the implementation of concurrent brachytherapy and hyperthermia treatments.

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EVALUATION OF DOSIMETRIC PARAMETERS OF GZP6 HDR BRACHYTHERAPY UNIT BY MONTE CARLO SIMULATION, TREATMENT PLANNING SYSTEM, RADIOCHROMIC FILM AND THERMOLUMINESCENCE DOSIMETRY

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[1]A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy of Mashhad University of Medical Sciences, Mashhad, Iran, 2011

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Evaluation of the accuracy of a treatment planning system plays a vital role in the quality assurance of the treatment of patients. The aim of this study is to assess dosimetric characteristics of a GZP6 brachytherapy unit, being used in Reza Radiation Oncology Center (in Mashhad, Iran). GZP6 ^{60}Co afterloading HDR unit (Nuclear Power Institute of China) has 6 channels with five non-stepping sources in channels 1-5 and a stepping source in channel 6. Dosimetric parameters introduced by Task Group No. 43 (TG-43) of American Association of Physicists in Medicine were obtained by MCNPX Monte Carlo (MC) code simulations for the GZP6 No. 3 brachytherapy source. Dose distributions around sources No. 1, 2 and 5 when loaded in tandem applicator were measured by radiochromic film (RCF) dosimetry. For this purpose EBT radiochromic film was employed. The latter results were compared with those obtained by simulation and the GZP6 treatment planning system (TPS). Maximum rectum and bladder doses incurred during 40 treatment sessions by patients who endured brachytherapy of cervical or vaginal cavity were measured. The rectum dose measurement was performed by thermo luminescence dosimetry (TLD) method. The TLD results were compared with corresponding values provided by TPS and also with the values reported by the Reza Radiation Oncology Center for rectum and bladder dose. Air kerma strength for source No. 3 obtained by in-air measurement, Monte Carlo simulation and TPS were respectively equal to 16991.83, 17240.01 and 15355 μGym^2h^{-1}. Dose rate constant for the source No. 3 was also obtained as 1.104 ± 0.03 $cGyh^{-1}U^{-1}$ by Monte Carlo simulation. Comparisons of dose distributions in the longitudinal plane acquired by the three mentioned methods for sources No. 1, 2 and 5 revealed that (when considering the associated errors with the methods) there is a good agreement between the results attained for sources No. 1 and 2 (differences of 4% and 7% exist between simulation and measurement respectively for sources 1 and 2; and differences of 4% and 5% exist between simulation and TPS respectively for sources 1 and 2). As sample, dose distributions around tandem applicator for source No. 1 from MC, GZP6 TPS and RCF dosimetry are presented in Figure 1 and Figure 2. However, the agreement is not so good for source No. 5 (differences up to 16% exist between simulation and measurement at some points). The average of maximum rectal and bladder dose values were found to be 7.62 Gy (range 1.72-18.55 Gy) and 5.17 Gy (range 0.72-15.85 Gy) respectively. A summary of measured rectum and bladder dose relative to the prescribed dose, in the form of various relative dose ranges and the number of cases in each dose range, is listed in Table 1. It has been recommended by the ICRU that the maximum dose to rectum and bladder in intracavitary treatment of vaginal or cervical cancer should be lower than 80% of the prescribed dose to point A in the Manchester system. In this study among the total number of 40 insertions, maximum rectal dose in 29 insertions (72.5% of treatments sessions) and maximum bladder dose in 18 insertions (45% of treatments sessions) were higher than 80% of the prescribed dose to the point of dose prescription. The results of

dose measurement for rectum are in agreement with the results acquired by the GZP6 treatment planning system. The agreement is poor for the bladder dose. The results of rectum and bladder dosimetry were different from the dose values reported by Reza Radiation Oncology Center for the dose of rectum and bladder. The dosimetric parameters acquired for the GZP6 source No. 3 can be used as input to the GZP6 treatment planning system toward improvement of the accuracy of dose values presented by this system. The accuracy of dose distributions achieved by the GZP6 treatment planning system for the sources No. 1 and 2 are acceptable, but dose distribution consistency accordingly in the regions near the tip and body of the applicator is not satisfactory. The differences between dose distributions for source No. 5 can be related to the errors in the activities of active pellets' present in this source, certified by the source manufacturer. In-vivo dosimetry for patients undergoing treatment by GZP6 brachytherapy system can be used for evaluation of the quality of brachytherapy treatments by this system. The information presented here can be used as a base for developing the strategy for treatment of patients treated with GZP6 system.

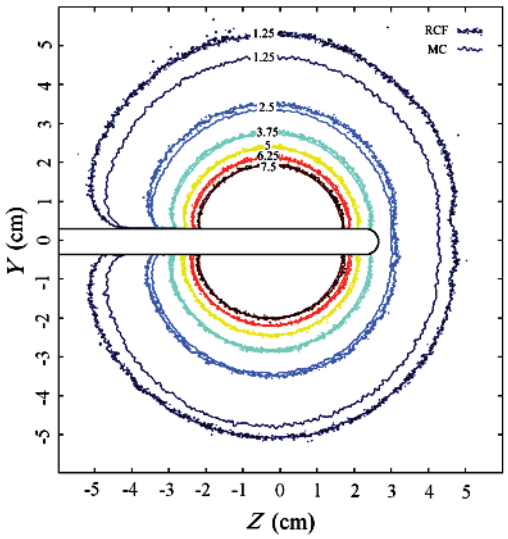

Figure 1. Dose distributions (in Gy) for the source No. 1 around the tandem applicator in longitudinal plane as obtained by RCF measurements and MC simulations.

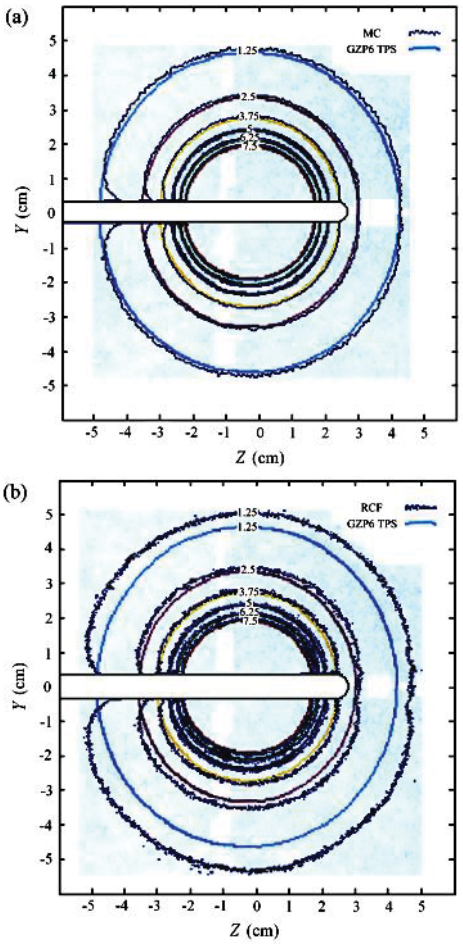

Figure 2. Dose distributions (in Gy) for the source No. 1 around the tandem applicator in longitudinal plane: (a) GZP6 TPS versus MC calculations, (b) GZP6 TPS versus RCF measurement.

Table 1. Summary of measured rectum and bladder dose relative to the prescribed dose.

Relative measured dose to the prescribed dose (%)	Number of cases	
	Rectum	Bladder
0-50%	5	12
50-100%	11	13
100-200%	14	12
200-300%	7	2
300-350%	1	1
350-400%	2	0

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WELCOME

Dear Colleagues

It is with great pleasure that we invite you to participate in the 20th International Conference on Medical Physics and Biomedical engineering (ICMP) in Brighton, UK from 1st - 4th September 2013 hosted, on behalf of the IOMP, by the Institute of Physics and Engineering in Medicine.

The conference will celebrate the 50th Anniversary of the foundation of the International Organization for Medical Physics (IOMP). The IOMP was formed in January 1963, initially with 4 affiliated national member organizations from the UK, Canada, Sweden and the USA.The first ICMP was held in Harrogate, UK so it is fitting that IOMP has returned to the UK to celebrate its 50th birthday. In addition, the conference incorporates the 7th European Conference on Medical Physics and 2013 Medical Physics and Engineering Conference.

There will be an opportunity to celebrate the vision and leadership of the founders as well as explore the contribution that physics and engineering can make to healthcare. The programme will showcase current research, educational and professional development, and the contribution of industry to the field of medical physics and biomedical engineering.

The conference theme is 'New Horizons - Global and Scientific'. The past 50 years have seen unparalleled applications of physics and engineering to healthcare and, without doubt, this will continue. Medical physics and biomedical engineering seek to translate basic research into application for the promotion of human health. This can only be achieved through collaborations which are both multi-disciplinary and multi national; ICMP will provide an ideal platform for fostering them.

IOMP may be 50 years old but it is a spritely 50 year-old; ICMP 2013 is an ideal place to celebrate this birthday and see what the future may hold for Medical Physics and Biomedical Engineering.

We hope to see you in Brighton in 2013.

Prof. Peter Sharp

ICMP 2013 President

Prof. Kin Yin Cheung

IOMP President

Prof. Peter Jarritt

IPEM President

ABOUT ICMP 2013

The ICMP congress and associated exhibition will be the foremost event showcasing developments in Medical Physics and Engineering in 2013. With a theme of New Horizons – Global and Scientific the event seeks to bring together researchers, educators, clinical and healthcare scientists and engineers, technologists, healthcare and estates managers seeking to apply science and technology to healthcare challenges throughout the developed and developing world. The conference will showcase the work of young researchers and will appeal to those in training as well as established professionals.

This conference incorporates the VIIth EFOMP European Medical Physics and Engineering Conference as well as the Annual Meeting of IPEM.

ICMP 2013

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ICMP 2013

DAY 1, TRACK 1

BASIC RT SAFETY

Invited Speaker

UK PERSPECTIVE ON RADIOTHERAPY PATIENT SAFETY

T.Leslie Frew

Head of Radiotherapy Physics Service, Cancer Centre, Belfast City Hospital, Lisburn Road, Belfast, BT9 7AB, Northern Ireland

Several high profile UK radiotherapy incidents dating back to the 1990's, all of which have been well publicised, prompted a commitment from the community to improve patient safety. In addition to several other initiatives there was a desire to establish a national database of all radiotherapy incidents to provide learning opportunities for the whole community. This would require radiotherapy facilities to report all incidents including those not reportable under regulation. It was recognised that this would require a culture change within the NHS to establish the process but that huge benefits could be realised for patients. A working party of involved stake holders, including professional bodies, produced a report making 37 recommendations. One of these was the establishment of a standardised reporting mechanism utilizing data that could be analysed and reported back to the radiotherapy community. The responsibility for taking forward the reporting process was entrusted to a Multi-disciplinary group – The Patient Safety in Radiotherapy Steering Group. Since 2008 this Group, have worked closely with the National Reporting & Learning System to optimise a national reporting mechanism for radiotherapy. They have encouraged reporting of radiotherapy incidents and produced reports of the analysed data together with guidance on how these events might be minimised. Over a period of 3 years the culture for reporting has grown across the UK and the regular analysis and feed-back disseminated through the involved professional groups. This talk will trace the key milestones in the development of this process and illustrate the changes being observed.

Invited Speaker

WHAT HAVE WE LEARNED ABOUT ERRORS AND SAFETY IN MODERN RADIOTHERAPY?

Benedick A. Fraass, Ph.D.

Department of Radiation Oncology, Cedars-Sinai Medical Center, Los Angeles, CA, USA

In the more than three years since articles in the New York Times and other media helped focus Radiation Oncology on safety and errors, a great deal of effort and attention has been focused on improving safety for patients treated with radiation therapy. The renewed attention to safety has led to many new organized projects, including the ASTRO safety white paper series (IMRT, IGRT, SBRT, Peer Review, HDR), the intersociety report "Safety Is No Accident" (from ASTRO, AAPM, ACR, AAMD, SROA, ASRT), as well as the creation of entirely new groups aimed at improving safety (e.g., the Radiation Oncology Safety Stakeholders Initiative, an independent group of physicists, physicians, therapists, dosimetrists, vendors, and RT organization representatives). Safety efforts have also included work by long-running working groups (e.g., AAPM Task Group 100) which are working to change the overall approach to quality management programs to more effectively apply our quality assurance and control efforts to the most important potential problems. The efforts of these groups have been supplemented by the many individual analyses, studies, projects, and other work by individuals and individual institutions. Study of the actual error rates for various procedures and treatment delivery processes can help us understand where our limited QA efforts should be expended, and are crucial to the actual improvement of safety in our individual clinics. This presentation will discuss available data on safety, errors and mitigation strategies, and put them into context with on-going safety enhancement efforts, with the goal of identifying how best to continue to improve the safety of all radiotherapy treatment.

Invited Speaker

SAFETY AND RISK MANAGEMENT IN RADIOTHERAPY : THE LESSONS LEARNED FROM HISTORY

Edwin Aird PhD FIPEM

Lead Scientist for QA in UK Radiotherapy Clinical Trials (ex-Head of Dept at Mount Vernon Cancer Centre)

Legislation associated with medical uses of radiation requires that a risk assessment be made. This is particularly necessary for the radiotherapy patient where the processes for planning and delivering radiotherapy are now very complex, and include the involvement of many different staff

We know from surgery, and particularly the use of anaesthetics, that the associated risks have now become better understood and that measures have been put in place to minimise the risks to the patient.

The various mistakes and errors that have been made around the world, and specifically in the UK, in radiotherapy will be described and discussed. The procedures and systems that are in place in the UK, including the Quality System for Radiotherapy-which became a mandatory requirement for all UK departments more than 25 years ago- will be presented which, together with other vital elements of a safety culture will demonstrate the optimum solution to minimise risk in the UK.

Other systems, such as FMEA, will be mentioned as possible alternative means to reduce serious errors to zero and minimise the less serious errors

Invited Speaker

REVISION OF IPEM GUIDANCE ON QUALITY CONTROL OF RADIOTHERAPY EQUIPMENT

Imran Patel[1], Antony Palmer2 (on behalf of the IPEM working party)

[1] *Christie Medical Physics and Engineering, The Christie NHS Foundation Trust, Manchester, UK*

[2] *Medical Physics Department, Queen Alexandra Hospital, Portsmouth, UK*

Fundamental to the aim of optimum, high quality, safe radiotherapy is robust and appropriate control of all physical aspects that may influence treatment. As the professional body for medical physics in UK, IPEM are revising their basic recommendations report for physics aspects of quality in radiotherapy.

To ensure treatment delivery is as proposed a quality assurance system in radiotherapy is essential. A quality control measurement program is a crucial component within a quality assurance system. Guidance on quality control (QC) of radiotherapy equipment was published by the Institute of Physics and Engineering in Medicine (IPEM) in 1999 in the form of Report 81. IPEM Report 81 was primarily based on results of a survey of UK QC practice that was undertaken in 1991. Since this publication dramatic technological advances in radiotherapy equipment and increasingly complex clinical use requires the guidance report to be reviewed and updated. A working party was approved by IPEM and setup in June 2012 for this purpose with eight expert members from the UK chosen to be on the editorial board. Several leading individuals within the field in the UK were approached to update report 81 content and to submit new subject matter that could be included in the publication of the revised guidance. The progress made by the working party so far and the proposed changes to the updated report will be considered.

Paper Number: 0160

MISDIRECTION AND 'SLEIGHT OF MIND': THEIR CONTRIBUTION TO RADIOTHERAPY ERRORS AND NEAR-MISSES.

Henry Lawrence

Ipswich Hospital, Ipswich, Suffolk, UK

Errors and near-misses in radiotherapy have many origins. Sometimes the cause is straightforward and sometimes extremely subtle. IAEA (1) have published a summary of 92 radiotherapy accidents, highlighting their immediate causes and the underlying contributory factors.

Stage magicians use the techniques of sleight of hand and misdirection in order to perform their illusions (2). An impressive illusion can be achieved by ensuring that the audience disregards a seemingly trivial detail, which is in fact the key to the deception. Some of the accidents and near-misses that have occurred have had causes that bear a striking similarity to stage conjurors' techniques. An example is an over-complicated piece of documentation that misdirects the reader. While grappling with the complexity of the problem the reader misses a simple inconsistency.

This talk describes several accidents and near misses in which misdirection and 'sleight of mind' have been key features. 'Sleight of mind' is sleight of hand when applied to mental processes. It is hoped that increasing awareness of the causes of these accidents and near-misses will contribute to improved procedures and clearer documentation.

1 Lessons learned from accidental exposures in radiotherapy. International Atomic Energy Agency, Vienna, 2000.

2 Every Trick in the Book. Charlie Dancey. Wooden Books (2010)

Invited Speaker

PATIENT SAFETY IN EXTERNAL BEAM RADIOTHERAPY – GUIDELINES ON RISK ASSESSMENT AND ANALYSIS OF ADVERSE EVENTS AND NEAR MISSES. OVERWIEW OF THE ACCIRAD PROJECT.

J Malicki[1,2], H Jarvinen[3], J Godet[4], A Skrobala[1,2], M Valero[4], A Jahnen[5], K Przybylska[1], P Maingon[6], M Krengli[7], R Bly[3]

[1] Greater Poland Cancer Centre, Poznan, Poland, [2] Electroradiology Department, University of Medical Sciences, Poznan, Poland, [3] Radiation and Nuclear Safety Authority (STUK), Helsinki, Finland, [4] ASN- Nuclear Safety Authority, Paris, France,[5]Public Research Centre Henri Tudor (TUDOR), Luxembourg, Luxembourg, [6] Centre Georges-Francois Leclerc, Dijon, France, [7] University of Piemonte Orientale, Novara, Italy

AIM

The main goal of the project was to perform an EU-wide study on implementation of the MED requirements aimed at reduction of probability and magnitude of accidents in radiotherapy and to develop guidelines on a risk analysis of accidental and unintended exposures in external beam radiotherapy.

DESCRIPTION OF THE PROJECT

The ACCIRAD Consortium consists of six partners: ESTRO, ASN with SECTOR, STUK, FIB HCSC , TUDOR and GPCC. The workload is divided into Work Packages: project management, questionnaire, risk analysis of accidental and unintended exposures, classification, reporting, registration of events, European Guidelines and Workshop.

RESULTS OF THE QUESTIONNAIRES:

The General questionnaire was sent to 38 countries, from which 21 have replied. The second questionnaire was completed by respective number of countries: detailed questionnaire -10, description of local proactive risk assessment/ and retrospective risk analysis -13, radiotherapy event report - 5, incident reporting systems- 20.The Draft Guidelines were discussed during European Workshop and were highly appreciated by all Invited organizations; including professional and scientific organizations

GUIDELINES

Throughout the project execution terminology evolved and the name of Draft Guidelines was altered from Guidelines on a risk analysis of accidental and unintended exposures in radiotherapy to Patient safety in external beam radiotherapy – Guidelines on a risk assessment and analysis of adverse and near misses. New terminology was proposed: adverse events instead of accidents, no harm or minor event, near misses. It was agreed to use the term ‘reporting and learning systems’, and a definition for ‘significant event.

ICMP 2013

DAY 1, TRACK 2

HTTG WORKSHOP ON DIGITAL IMAGING X-RAY DETECTORS: HISTORICAL PERSPECTIVES, CURRENT CAPABILITIES, FUTURE PROMISES

Invited Speaker

THE HEALTH TECHNOLOGY TASK GROUP OF THE INTERNATIONAL UNION FOR PHYSICAL AND ENGINEERING SCIENCES IN MEDICINE

C. Borrás, D.Sc.

Chair IUPESM/HTTG

The mission of the Health Technology Task Group (HTTG) of the International Union for Physical and Engineering Sciences in Medicine (IUPESM) is to assist countries in defining their health technology needs, and to identify and rectify health system constraints for adequate management and utilization of health technology, particularly through training, capacity building and the development and application of appropriate technology. To provide guidance, one of the HTTG charges is to organize scientific workshops on current technology challenges in the medical field. Previous workshops addressed: “Palliative Radiotherapy”, Ho-Chi-Minh City, Vietnam 2008; “Defining the Medical Imaging Requirements for a Rural Health Center”, Porto Alegre, Brazil 2011, and “Telemedicine for Developing Countries”, Beijing 2012, China. This workshop deals with “Digital Imaging X-ray Detectors: Historical Perspectives, Current Capabilities, Future Promises” and will present the state of the art of digital detectors, including their imaging and radiation characteristics; describe current clinical applications and novel approaches; analyze costs and transition problems from analog to digital imaging, and discuss patient safety. As in previous workshops, it is expected that after reviewing the issues, recommendations will be drafted and published.

Invited Speaker

HISTORICAL DEVELOPMENT OF CR/DR AND NEW DETECTOR TECHNOLOGIES

J. Anthony Seibert, PhD

Department of Radiology, University of California Davis Medical Center, Sacramento, California, USA

Digital x-ray detectors have evolved over the past 40 years, beginning with simple digitization of film images with a “camera on a stick”, through development of photostimulable phosphor technology commonly known as “Computed Radiography” as a direct replacement for screen-film, slot-scan area detectors, to the introduction of flat-panel active matrix thin-film transistor (TFT) array detectors, which now represent the current state-of-the-art technology that is being widely adopted. New technologies being implemented or under development include large field of view detectors using Complementary Metal-Oxide Semiconductor (CMOS) arrays, novel low-cost detectors using LCD panels with line-scan readout methods, variable gain TFT flat panels, and energy discrimination photon-counting detectors, among many recent innovations. A brief historical review, a description of current detector technology capabilities, followed by the anticipated opportunities and promise of future detectors for projection radiography comprise the contents of this presentation.

Invited Speaker

IMAGE QUALITY PARAMETERS AND THEIR MEASUREMENT

John M. Boone, Ph.D.

Department of Radiology, University of California, Davis, Sacramento, CA, United States of America

In the era when medical imaging systems were analog (e.g. screen film radiography), the measurement of image quality - primarily spatial resolution and noise properties -was typically performed using subjective metrics based on visual assessment of images produced using resolution templates and contrast detail phantoms. With the advent of digital x-ray detectors for fluoroscopy, radiography, and mammography, the opportunity arises for a more quantitative assessment of spatial resolution and noise properties of an imaging system. The modulation transfer function (MTF) is used to characterize the spatial resolution of an imaging system, and provides a quantitative understanding of detector resolution over a range of object dimensions. The noise properties of the digital x-ray system are characterized using the noise power spectrum (NPS), which describes the noise texture properties of the system. Other derived metrics such as the noise equivalent quanta (NEQ) and the detective quantum efficiency (DQE) are also very important in regards to characterizing the performance of digital imaging detectors. A qualitative and quantitative discussion of these important image quality metrics is the focus of this presentation.

Invited Speaker

LOW COST DIGITAL DETECTOR TECHNOLOGY FOR EMERGING ECONOMIES

Karim S Karim

Department of Electrical and Computer Engineering, University of Waterloo, Waterloo, Canada

Cost and accessibility are major barriers to x-ray medical diagnostics in low-income countries. For example, sputum, blood and urine tests are slower, and difficult to administer in remote locations, having high associated transportation and storage costs. We believe a digital x-ray system could be a solution for lowering the cost of accurate, timely diagnostics in emerging economies. However, the cost of medical-grade digital x-ray imaging systems today is prohibitively large and poses a hurdle to many potential customers except major hospitals in urban centres, thus preventing the early diagnosis of many curable diseases. In this talk, we discuss an ideal digital X-ray system for emerging economies that would cost below $10,000 to manufacture and is achievable today using a combination of commodity and industrial products, region-of-interest imaging, and an optimization of technical requirements for a set of prioritized imaging tasks.

Invited Speaker

DOSE METRICS: NEW "EXPOSURE INDEX" FOR DIGITAL RADIOGRAPHY

J. Anthony Seibert, PhD

Department of Radiology, University of California Davis Medical Center, Sacramento, California, USA

The separation of image acquisition and image display for digital radiography devices uncouples the relationship between detector exposure and image appearance, with the potential for needless patient overexposure. The Exposure Index is currently a method in which digital radiography manufacturers provide feedback regarding the estimated exposure on the detector, as a surrogate for image signal to noise ratio and an indirect indication of digital image quality. Unfortunately, there are as many Exposure Index values/methods as there are manufacturers, which make the situation even more complicated and confusing. A new Exposure Index for digital x-ray imaging systems has been implemented as an international standard by the International Electrotechnical Commission. As explained, the Exposure Index does not indicate patient dose, but an estimate of the incident radiation to the detector. However, the standardized Exposure Index (EI)and its associated Target Exposure Index (EIT) and Deviation Index (DI) values should lead to improved performance in terms of uniformity, standardized terminology, and use of optimized radiographic techniques, with the likelihood of better and safer care of patients. Procedural Diagnostic Reference Levels based on these indices should provide guidance to users.

Invited Speaker

FLAT PANEL DETECTORS FOR CLINICAL CONE BEAM CT APPLICATIONS

John M. Boone, Ph.D.

Department of Radiology, University of California, Davis, Sacramento, CA, United States of America

Flat-panel detectors, developed initially for radiography and fluoroscopy applications, are the enabling technology for cone beam computed tomography (CT). Flat-panel detectors have traditionally been manufactured using thin-film transistor technology, however more recently large detector arrays have been produced from smaller area detector systems, abutted next to one another. Complementary metal oxide semiconductors (CMOS) detectors are more widely used today. For flat panel detectors to be useful in cone beam CT applications, the frame rate of the system needs to be high, typically exceeding 30 frames per second or greater. There are several clinical applications of cone beam CT, including CBCT systems for image guidance in radiation therapy, C-arm CT systems for angiography and surgical applications, dental CT systems, small animal imaging, and breast CT. A brief overview of the technology of flat-panel detector systems will be provided, followed by some clinical examples. Some of the limitations of cone beam CT will also be discussed.

Invited Speaker

CLINICAL APPLICATIONS: DIGITAL DETECTORS FOR MAMMOGRAPHY

Kwan-Hoong Ng.

Department of Biomedical Imaging, University of Malaya, Kuala Lumpur, Malaysia

The X-ray detector is the key component of a digital mammography system. The detector interacts with the x-ray photons transmitted by the breast and absorption of the photon energy, followed by performing several other important functions. These other functions include: conversation of the transmitted and absorbed energy to a usable signal (light or electronic charge), collection of this signal, secondary conversion if needed (phosphor-based detectors), readout of the charge, amplification, and finally digitization of the information.

This talk reviews the detector technologies used in digital mammography that could be categorised as direct and indirect technology. There are two types of direct technology depending on the x-ray photon conversion process (a) direct-to-digital radiography (aSe technology and photon counting) and (b) indirect-to-digital radiography (CsI/aSi technology and charge-coupled device technology). The indirect technology is the computed radiography (CR) utilising the photostimulable storage phosphor technology. Detector performance characteristics vary among these different technological approaches. An understanding of the physics on which detector operation is based can help explain these differences. The overall imaging performances of digital mammography depend on the optimization of characteristics such as: dynamic range, sensitivity, detective quantum efficiency and modulation transfer function. Overall performances are often the result of compromises in the choice of technology.

Invited Speaker

REGION OF INTEREST TUBERCULOSIS SCREENING

Ryan Mann, Karim S Karim

Department of Electrical and Computer Engineering, University of Waterloo, Waterloo, Canada

We propose a low-cost, digital x-ray system for screening of tuberculosis in a fast, accurate way to empower rural areas in developing countries to diagnose TB early. The low-cost system is designed to capture an image of one lung at a time in contrast to current state-of-the-art medical-grade chest x-ray detectors. To determine the system's minimum requirements, an investigation into region-of-interest tuberculosis diagnosis was initiated, with the question: Can TB be accurately diagnosed when the lungs are displayed in cropped single-lung images? Volunteer radiologists in a medical study were asked to screen for signs of tuberculosis in full size chest x-rays and in cropped single lung images, both obtained from a commercial digital chest X-ray imager. Preliminary results indicate that the sensitivity and specificity of tuberculosis diagnosis using full size digital chest X-rays is similar to that obtained using cropped single lung images.

Invited Speaker

TRANSITION FROM SCREEN-FILM TO DIGITAL RADIOGRAPHY: PRACTICAL ADVICE

Kwan-Hoong Ng.

Department of Biomedical Imaging, University of Malaya, Kuala Lumpur, Malaysia

Many countries are currently transitioning from screen-film radiography to digital radiography. Most principles for dose reduction in screen-film radiography, including justification and optimisation, are relevant to digital systems. However, digital systems have the potential to significantly increase patient dose, possibly due to lack of awareness among imaging personnel. Examination parameters, such as tube voltage, tube current, and filtration have been adopted from screen-film technology without further adjustments. The imaging parameters must be optimised according to the best performance of a particular system. Current safety issues with clinical digital radiography are discussed; these are technology factors, such as automatic exposure factors, exposure index; and human factors such as inappropriate exposure, no collimation, overexposure, etc. Digital techniques increasingly offer options for dose reduction; however the full potential has yet to be realised. Therefore, implementation of dose indicators and dose monitoring is mandatory for digital radiography in practice.

Invited Speaker

RADIATION PROTECTION OF PATIENTS AND THE USE OF DIAGNOSTIC REFERENCE LEVELS IN DIGITAL RADIOLOGY

E. Vano

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The International Commission on Radiological Protection (ICRP) published a document on 'Managing patient dose in digital radiology' in 2004. Digital techniques offer great potential for better practice in radiology but also increase the risk of overusing radiation. The main advantages of digital imaging (wide dynamic range, post-processing, multiple viewing options, electronic transfer and archiving possibilities) are obvious, but overexposures can occur without an adverse impact on image quality. Digital radiology requires specific training for radiologists, radiographers and medical physicists. Patient doses can be easily estimated, registered and transferred to the patient examination reports and image quality (or diagnostic information) can be tailored to the clinical problems. When commissioning digital systems, it should be ensured that imaging capability and radiation dose management are integrated to achieve acceptable clinical imaging using appropriate patient doses. Justification and optimization criteria should be the key components to be considered in the update of a quality assurance programme when a facility converts to digital imaging. The Diagnostic Reference Levels (DRLs) introduced by ICRP in 1990 with a view to identifying unusually high levels of patient dose are especially useful in digital imaging to determine that the imaging system and the imaging acquisition protocol and processing have been adequately optimized. In 2001, ICRP provided additional advice on the application of DRLs in interventional radiology. With digital techniques, the exploitation of the full individual patient dose distributions is available to help with optimization in addition to DRLs.

ICMP 2013

DAY 1, TRACK 3

SHIELDING AN X-RAY DEPARTMENT A WORKSHOP

ICMP 2013

DAY 1, TRACK 3

THE IOMP: PAST, PRESENT AND FUTURE

Invited Speaker

THE IOMP: PAST, PRESENT AND FUTURE

Peter H S Smith

Former Secretary-General, IOMP

Following the formation of IOMP in 1963, an early task was the organizing of an international medical physics conference and this took place in Harrogate, UK, in 1965. This conference and the history of subsequent conferences, up to the current one celebrating the 50th Anniversary conference of IOMP, which is the 20th conference of the IOMP series of International Conferences on Medical Physics, will be discussed. Links to the International Federation of Medical and Biological Engineering leading to the formation of the International Union of Physical and Engineering Sciences (IUPESM) and to holding of World Congresses on Medical Physics and Biomedical Engineering will be outlined, as will the events leading to the membership by IUPESM of the International Council of Science (ICSU). IOMP, representing the worldwide medical physics community, has over the years developed formal and informal links with international organisations, such as the World Health Organization (WHO) and the International Atomic Energy Agency (IAEA), and the evolution of these contacts and the development of two programmes, the Used Equipment and the Library Programme, to assist medical physicists in developing counties, will also be reviewed.

Invited Speaker

HISTORICAL OVERVIEW OF: MEDICAL PHYSICS WORLD (MPW-EMPW), INTERNATIONAL SCIENTIFIC EXCHANGE PROGRAMS (ISEP), MEDICAL PHYSICS RECOGNITION BY INTERNATIONAL LABOR ORGANIZATION (ILO), THE INTERNATIONAL STANDARD CLASSIFICATION OF OCCUPATIONS (ISCO-2008).

Azam Niroomand-Rad, PhD, DSc

Professor Emeritus, Georgetown University Medical Center, Washington DC, USA

IOMP Past-President, Chair History Sub-Committee

(A) To establish communication with all the medical physicists worldwide, IOMP's first publication of Medical Physics World (MPW) was launched in 1984; Lawrence Lanzl, Editor. With two issues per year, 25 Volumes were published in 25 years. In 2009 hardcopy prints were discontinued and electronic version (eMPW) became available at IOMP website.

(B) To improve education and training of medical physicists, in 1989 Azam Niroomand-Rad initiated International Scientific Exchange Programs (ISEP) in the American Association of Physicists in Medicine (AAPM). The goal was also to establish medical physics societies where none existed and to encourage them to join IOMP. Thus these programs have been co-sponsored by IOMP since 1991. Initially there was one ISEP per year in therapy (ISEP-T). But additional ISEP in diagnostic and nuclear medicine (ISEP-D) has been offered since 2002. Currently 22 ISEP-T and 12 ISEP-D/NM have been offered in 24 (mostly) developing countries and 10 national medical physics societies were established.

(C) To achieve medical physics recognition by the International Labor Organization (ILO), in 1995 Keith Boddy wrote to ILO requesting inclusion of medical physics as new Health Professional in next revision of International Standard Classification of Occupations (ISCO-88). Soon after, the IOMP Presidents including Colin Orton and Azam Niroomand-Rad realized this path was long and had to " jump, climb over, go around, go through, or tunnel under" to overcome many unforeseeable obstacles. Our request with supporting documents was resubmitted few times in several sequential stages. This included tally of medical physicists, tasks and duties performed, education, training, and certification required to work as Health Professional. ILO twice consulted governmental labor organizations, statistical institutes and international organizations to collect information on status of medical physicists and in which Unit Group they should be listed. In 2007 revision of ISCO-88 was approved by the ILO Governing Body at the Meeting of Experts in Labor Statistics. After 20 years, (ISCO-08) was updated and medical physicists were listed in Major Group 2 (Professionals), Sub-Major Group 21 (Science and Engineering Professionals), Minor Group 211 (Physical and Earth Science Professional), and Unit Group 2111 (Physicists and Astronomers) with a note "medical physicists are considered to be an integral part of the health work force alongside those occupations classified in Sub-Major Group 22, Health Professionals and others classified in other unit groups in Major Group 2".

Invited Speaker

IOMP- THE FUTURE

Kin-Yin Cheung, Ph.D., President, IOMP

Hong Kong Sanatorium & Hospital, Hong Kong

IOMP has in the past 50 years gained a lot of ground in promoting the global development of medical physics. However, medical physicists (MP) practicing as health professionals, especially those in developing countries are still facing many challenges. There is still a general lack of state recognition and awareness of our profession and on our role and responsibilities in healthcare; no consensus amongst the countries on the educational and training needs of MP; a general lack of accreditation on professional qualification and hence large variations in standard of practice of MP in different countries and within countries; and a shortage in the supply of qualified or trained MP in many countries. A major part of all these problems may be due to MP are not considered by government and health policy makers as health professionals. Currently, MP are rather invisibility in the health industry. They do not have an identity of their own as they are divided between scientists and health professionals. IOMP and NMOs should review and explore, among other things, whether MP working in the clinics and those working as scientists in R&D laboratories should have different training programs. They should consider whether the former should be trained as health professionals in a similar format and manner as other health professionals. They should explore to widen the scope of clinical service and service structure to improve clinical services and strengthen the visibility and professional identity of MP in healthcare.

ICMP 2013

DAY 1, TRACK 4

CT STUDY DAY
PHYSICS AND TECHNOLOGY
AND PRACTICAL ASPECTS

ICMP 2013

DAY 1, TRACK 5

THERMAL IMAGING CAMERAS

Invited Speaker

PIONEERS AND PROGRESS IN MEDICAL THERMOGRAPHY

Francis J Ring Dsc

Medical Imaging Research Unit, University of South Wales. Pontypridd UK

Infrared thermal Imaging for human body temperature requires knowledge of human physiology, body temperature in health and disease.

In 1800 William Herschel investigated the heat of each colour of the visible spectrum using a prism in a beam of sunlight. He established that the maximum heat was found just beyond the visible red, now known as infrared radiation. His son John in 1840 studied this with focused sunlight on a film of carbon particles in alcohol, and the image created he called a thermogram. Thus father and son were pioneers in obtaining a thermal image.

Advances in temperature studies were made by Carl Wunderlich who in 1870 created the clinical thermometer. In the early 20th century great progress was made by Rudolph Cobet in knowledge of human body temperature. His detailed work on skin temperature focused on the physical properties of skin, and its temperature regulation. He and Bramiqk proposed a simple radiometer. This led to the papers of James Hardy in 1935 showing that human skin behaves as a black body. In the late 1950's Drs Ray Lawson (Canada) and Kenneth Lloyd Williams (England) used radiometric measurements of skin temperature to study malignant breast diseases.

The early imaging systems came into clinical use in the late 1950's and early 1960's with cooled detectors, (indium antimonide, and mercury cadmium telluride). Clinical applications now include dynamic studies, stress testing and non invasive monitoring. The modern deployment of thermal imaging in airport screening for fever during alerts of high infection risk has led to an International Standard for this application of thermal imaging.

ICMP 2013

DAY 1, TRACK 5

MP EDUCATION FOR UNDERGRAD STUDENTS

Invited Speaker

UNDERGRADUATE EDUCATION IN MEDICAL PHYSICS AND BIOMEDICAL ENGINEERING – TRENDS AND CHALLENGES

S Tabakov

King's College London, UK

The inclusion of Medical Physics (MP) and Biomedical Engineering (BME) in the International Standard Classification of Occupations (ISCO-08) opens new horizons, but also challenges in front of the profession. One of these is the need for re-organisation of the current education to absorb the increasing growth of professional knowledge. The problem of including the large volume of MP and BME education into the limited number of Postgraduate (MSc-level) contact hours already creates challenges to the educators. One obvious outcome is launching Undergraduate (BSc-level) programmes in MP and BME. This process has started in a number of countries. This paper gives a brief review of international experience in the field, as well as our experience from opening a BEng in Biomedical Engineering in King's College London. At present such BSc-level programmes are predominantly in the field of BME, which is arguably due to the international discussion in this field, initiated during the 1980-ties. The World Conference of UNESCO 'Physics and Sustainable Development', (Durban, 2005) underlined one of the main areas of applied physics as Physics for Health. This opened up new opportunities for the profession and also created the need to broaden its scope. The main aim of the paper is to specify areas of existing experience and future needs, as well as to trigger discussion, which could lead towards development of guides for such programmes.

Invited Speaker

WHAT MEDICAL PHYSICS SHOULD WE TEACH MEDICAL AND DENTAL UNDERGRADUATES AND HOW?

E. Vano

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WHAT WE TEACH

In many Medical and Dental Schools, the fundamentals of Medical Physics (MP) are taught but with different contents depending on the curricula of the Universities and Faculties, on the Department MP is attached to, on the interest and priorities this Department shows for research and on the possible implication of medical physicists in clinical work at university hospitals.

The different learning objectives related to knowledge, skills and competences (KSC) should be agreed upon with the Departments of Medical and Dental schools concerned and take into account the needs that other disciplines included in the curricula have of fundamentals in Physics . Various aspects of radiation physics and radiation protection required by the national or regional regulations need to form a relevant part of the contents, as is the case in the European Union. Fundamentals of MP should also contribute to provide the students with the scientific methodology and the basis of the new advances in technology used in diagnostic and therapy..

HOW TO TEACH

Proper teaching of MP fundamentals to undergraduate students in Medical and Dental schools requires presenting the different topics in context with clinical problems specific to Medicine or Dentistry. The students need to know the dynamic of fluids for a good understanding of human physiology, some basic mechanics for that of anatomy, the physics of sound and of optics to understand diagnosis and treatment of hearing and vision pathologies etc. Diagnostic imaging and therapy require knowledge of ionizing and non ionizing radiations and of their interaction with biological matter as well as the basis of imaging and therapy systems. The fundamentals of radiation protection of patients and staff must also be addressed to justify imaging with ionizing radiations.

Teaching could be provided through conventional lectures, occasionally combined with seminars in small groups aimed at promoting students' skills in numerical calculation, at teaching methodology to measure different physical quantities in laboratories and at estimating the importance of experimental inaccuracies. Individual activities requiring the use of bibliography and Internet sources should also be promoted as part of the KSC agreed content. Professors should be familiar with the contents of all curriculum subjects as well as with the research activities of the different Departments so as to introduce relevant examples on the need of physics. The evaluation of students should be based on conventional assessment as well as continuous evaluation of their personal work to fulfil all the catalogue of KSCs.

Invited Speaker

WHAT AND HOW SHOULD WE TEACH PHYSICS AND BIOMEDICAL ENGINEERING UNDERGRADUATES.

Kwan-Hoong Ng.

Department of Biomedical Imaging, University of Malaya, Kuala Lumpur, Malaysia
(ngkh@um.edu.my)

The teaching of medical physics has been introduced to undergraduate physics and biomedical engineering curricula for many years. It varies from an elective course in the final year, as a minor, to a full-fledge Bachelor of Science in medical physics. However there are still concerns and debates as to what and how we should teach medical physics. My talk will first survey selected undergraduate programmes, where medical physics is being taught, in countries such as Australia, Canada, United Kingdom, and USA.

I recommend adopting a balanced approach. The relative content of physics/mathematics compared with medical physics courses is necessarily strongly dependent on the goal of each degree programme. For a student who wishes to pursue graduate studies in medical physics on the path to a career as a professional medical physicist then an undergraduate programme with a strong emphasis on physics and mathematics is crucial.

The teaching should be enthusiastic to introduce the exciting world of how physics and engineering are applied to medicine. Inviting clinical medical physicists to give a few guest lectures will enhance the real world experience, coupled with visits to a local hospital.

Some of the main courses that have been taught include structure and function of the body, physics of the human body, physics of living systems, biomedical instrumentation, introduction to medical imaging, introduction to radiotherapy, and introduction to nuclear medicine. Furthermore, an internship or attachment should be designed to provide opportunities for undergraduate students to gain experience in medical physics by performing research in a medical physics laboratory or assisting with clinical service at a healthcare facility.

ICMP 2013

DAY 1

WORKSHOP SESSIONS
MEDICAL PHYSICS IN AFRICA

Invited Speaker

IOMP WORKSHOP "MEDICAL PHYSICS IN AFRICA – STATUS AND WAY FORWARD"

Slavik Tabakov

Vice-President IOMP, King's College London, UK

Contemporary healthcare is impossible without medical technology. Due to this reason the demand for specially trained medical physicists and engineers increases rapidly worldwide. The problem in some countries is not the lack of medical equipment, but the lack of well-trained specialists to operate and maintain it efficiently and safely. The International Organization for Medical Physics (IOMP) is charged with a mission to advance medical physics practice worldwide by disseminating scientific and technical information, fostering the educational and professional development of medical physics and promoting the highest quality medical services for patients.

IOMP and its Regional Organisations (RO) have led a number of events to help professional development in various countries and regions. The first International Conference on Medical Physics Education and Training (Budapest 1994) was pivotal for the advancement of medical physics education and training in Eastern Europe. The experience from this Conference was transferred to Asia through several International Workshops, satellite to the 2003 World Congress on Medical Physics and Biomedical Engineering in Sidney and the 2006 World Congress in Seoul (where a large activity took place "Medical Physics and Engineering Education and Training – a global perspective"). The materials and activities of these events are described in the e-books at: http://www.emerald2.eu/mep_index.html. Similar activities were further carried out in Latin America, notably the Education and Training Workshop at the International Conference on Medical Physics ICMP2011, Porto Alegre, Brazil. The results from these events are seen in the rapid growth of medical physics in Asia and Latin America.

The present IOMP Workshop "Medical Physics in Africa – status and way forward" aims to transfer this experience to the African continent. Special support for the activity was received from the International Union for Pure and Applied Physics (IUPAP), and also through the channels of the International Atomic Energy Agency (IAEA) and the World Health Organisation (WHO). This Workshop, satellite to the International Conference on Medical Physics ICMP2013, Brighton, UK, will also include a Round Table discussion planning further activities in the region with the support of the IOMP RO – the Federation of African Medical Physics Organisations (FAMPO).

The IOMP Work Group charged with the organisation of this Workshop includes Prof. Fridtjof Nuesslin, Dr Raymond Wu, Dr John Damilakis, Dr Madan Rehani, Dr Taofeeq Ige, Dr Ahmed Seddick and Dr Slavik Tabakov (Chair). The materials from the Workshop, will be added to a new e-book, planned for the next year.

Paper Number: 0278

MEDICAL PHYSICS IN SOUTH AFRICA: A HISTORY AND CURRENT STATUS REPORT

William Rae

University of the Free State, Bloemfontein, Free State, South Africa

INTRODUCTION

The use of radiation for cancer treatment in South Africa (SA) apparently started in the 1950's with the application of 226Ra, but records are not available as to who imported these first isotopes. What is clear is that foreign (UK) qualified physicists were being employed at the time and the profession was established around the country.

HISTORY

The first physicists started assisting with the application of isotopes and x-rays in medicine in the mid 1950's. Amongst these was Prof Alan Cormack who carried out the first prototype experiments as a forerunner of Computed Tomography in Cape Town in 1956. In the same year Medical Physics as a profession was first recognised by the then Atomic Energy Board when regulations were published requiring registration of "hospital physicists". It required one year in-service training at a recognized training hospital after the MSc degree in Physics, and two years after a BSc (Hons) degree. SA thus became one of the first countries in the world to regulate the profession.

CURRENT STATUS

Medical Physicists are evenly spread between private and public sector hospitals around SA, predominantly serving the needs of radiotherapy centres, but also active in radiology, calibration laboratories, nuclear medicine and regulation. SA is self-sufficient in education, registration and training, also playing a role in supporting education in the region.

CONCLUSION

Medical Physics is a well-established profession in SA with a proud history stretching back many decades and is growing actively to fill the ever increasing need for skills as technology advances.

Paper Number: 0333

MEDICAL PHYSICISTS IN AFRICA - CONSOLIDATING THE DATABASE.

Taofeeq A. Ige[1], Ahmed Ibn Seddik[2], Rebecca Nakatudde[3], Khaled El-Shahat[4]

[1]FAMPO, ABUJA, FCT, Nigeria, [2]FAMPO, RABAT, Morocco, [3]FAMPO, KAMPALA, Uganda, [4]FAMPO, CAIRO, Egypt

The dearth of complete database of the Medical Physicists in the African continent has been identified as one of the urgent assignment that needs to be tackled by the FAMPO (Federation of African Medical Physics Organisations) Executive committee members (ExCom).

A survey conducted in the region in the course of executing the IAEA inter-regional project INT/6/054 - Strengthening Medical Physics in Radiation Medicine - tangentially provided some information in this regard but this is not sufficient.

The FAMPO ExCom seized the opportunity of the Project Coordinators Meeting (PCM) of the two International Atomic Energy Agency (IAEA) regional medical physics projects in Africa (RAF/6/038 - Promoting Regional and National Quality Assurance Programmes for Medical Physics in Nuclear Medicine and RAF/6/044 - Strengthening Medical Physics in Support of Cancer Management - Phase II) in 2012 to launch a data collection effort meant to address this dearth of information.

This presentation will highlight the progress made so far towards achieving a consolidated data base for the entire region. This will also provide information for an ongoing initiative of the IOMP to know the number of female medical physicists in the constituent regional federations.

Invited Speaker

THE ACADEMIC ROLE IN PREPARING A QUALIFIED MEDICAL PHYSICIST: CAIRO UNIVERSITY EXPERIENCE

Ehab M. Attalla[1, 2]

[1] Radiotherapy & Nuclear Medicine Department, National Cancer Institute, [2] Cairo University, Children Cancer Hospital, Cairo, Egypt

An essential question was facing the medical physics community; estimation of the supply and the demand for the qualified medical physicists through the next era. The Academic Role in Preparing a Qualified Medical Physicist is needed to decrease the gap between the applied and academic Medical Physicists. These academic aspects in the institutions may help in preparing a qualified Medical Physicist. Also increasing the frequency of teaching and formal training activities in the centers; establishment an education and training program in Zones (three to five countries) and affiliated to the university to promote the education and training program were led to that. The entrance requirement to that program is an undergraduate degree in this specialty.

Paper Number: 0330

MEDICAL PHYSICS RESIDENCY PROGRAMME IN A RESOURCE CONSTRAINED SETTING:THE NIGERIA EXPERIENCE.

Taofeeq A. Ige[1], Yakov Pipman[2]

[1] National Hospital, Abuja. FCT 900001, Nigeria, [2] AAPM, New York, NY 11375, USA

The current trend in Radiation Therapy in developing countries is to deploy new equipment with advanced capabilities to narrow the gap with the state-of-the-art.

The equipment is only one component of the resources needed for its safe and effective utilization. Manpower training is probably the most critical element in the equation. The practical training of Medical Physicists is one of the major hurdles in making a safe transition possible in Africa. This training is typically achieved in a residency programme.

Typically these programmes evolve organically in large, well equipped and well staffed medical centres over a period of a decade or more.

In developing countries, there is commonly a shortage in all these three areas and the common situation does not allow the luxury of this length of times.

Against this background we shall discuss the experience garnered so far with the recently launched national medical physics residency programme in Nigeria.

We will discuss the features of the programme along with issues of institutional, national and international support, and its strengths and limitations.

We will present the main lessons and challenges learned so far in this programme.

Invited Speaker

TOWARDS AN HARMONIZED SYLLABUS FOR ACADEMIC AND CLINICAL TRAINING IN MEDICAL PHYSICS FOR AFRICA

Ahmed Ibn Seddik

Consultant, Medical Physicist, ahmed.ibnsdeddik@gmail.com, Rabat, Morocco

President, Federation of African Medical Physics Organizations (FAMPO)

Project Scientific Consultant, RAF 6044, IAEA/AFRA

Radiation medicine in Africa is in an expansion. Most countries have already introduced radiation oncology, radiology and nuclear medicine in their hospitals to diagnose and treat patients. The shortage of clinically qualified medical physicist (CQMP) is an acute problem in Africa. Only few countries have established an academic postgraduate programme in medical physics and less more have clinical training programme. To encourage the implementation of such programmes, the International Atomic Energy Agency (IAEA) through its Section of Dosimetry and Medical Radiation Physics, and under AFRA Projects, organized meetings to develop harmonized approaches to the recognition and education of medical physicists in the region. This process started on 2001 and on 2013 there are 2 documents have been published:

- report of a task force meeting on a regional postgraduate medical physics syllabus for academic programmes,

- a regional clinical training programme for radiotherapy medical physics, report of a task force meeting.

The 2 documents have been endorsed by FAMPO as the concerned regional organization in medical Physics.

The first document presents the recommendations for harmonized postgraduate academic education of medical physicists in the region including radiation oncology, radiology and nuclear medicine.

The second one is based on the IAEA Technical Course Series No. 37 (2009) which provides guidelines for the clinical training of medical physicists specializing in radiation oncology. Other meetings are planned on 2014 to produce a document for clinical training in imaging including radiology and nuclear medicine.

Paper Number: **0029**

GROWING RADIOTHERAPY IN NIGERIA THROUGH SUSTAINED, TARGETED TRAINING - A SUCCESS STORY.

Ado Janse van Rensburg

Steve Biko Academic Hospital, Pretoria, Gauteng, South Africa

During my involvement in the commissioning of Radiotherapy Departments in Nigeria, I identified that the personnel in these departments, while all are dedicated professionals, were not equipped to run these departments. In my mind the best way to get these units to function would be to train a team from each hospital together and to follow it up with on-site application training.

A three month course, offered at our hospital, was designed consisting of a short academic refresher and practical hands-on training culminating in the drafting of Departmental policies and procedures. Ideally a team consisting of a Radiation Oncologist, two Radiotherapy Radiographers and one Physicist attended. General as well as profession specific training were offered.

Two week on site application training was given on completion of the course to help iron out unit specific problems. At the conclusion of the project a practical training sessions was given to representatives of all the centres in Benin City, Nigeria. A team consisting of a Planning Radiographer, Radiation Oncologist and me (Medical Physicist) helped to fine tune procedures.

A large number of lessons were learnt by all during this process. History will tell if this approach is the best solution to establishing radiotherapy in Africa. The initial signs are encouraging.

I would like to acknowledge the crucial role played in the success by:

LUTH, UNTH, UDUTH and UBTH Nigeria as well as Dr Taofeeq IGE

Steve Biko Academic Hospital, Dr A Hocepied and J Schoeman

Vamed Engineering Vienna, M Schoenthaler

Invited Speaker

ROLE OF NUCLEAR MEDICINE IN THE SUPPORT OF CANCER MANAGEMENT IN GHANA

Francis Hasford[1]

[1]Radiological & Medical Sciences Research Institute, Ghana Atomic Energy Commission, Accra, Greater Accra, Ghana

Ghana received its first SPECT system in 2005. With diagnostic accuracy being a target in nuclear medicine imaging, performance evaluation tests were successfully performed on the installed Siemens e.cam® SPECT system at Korle-Bu Teaching Hospital in Ghana according to NEMA protocols. On the basis of satisfactory testing results, the Siemens SPECT system has been applied in number of studies including thyroid, renal and bone scintigraphy. Since installation of the system, bone imaging has accounted for ~83% of scintigraphic studies at the Hospital. Female reported cases have dominated over male reported cases, with peak age at bone tumour detection between 51 and 60 years. Diagnosed bone tumours with their origin in the cells of bone itself have been found to be less prevalent relative to metastasize tumours, notably the prostate. Diagnosed metastatic bone tumours due to spread from prostate cancers have contributed to 19% of bone tumour cases reported. With PET's ability to provide images of better resolution and sensitivity than SPECT, the study has been extended to focus on improvement of diagnostic accuracy through development of improved codes for fusion of prostatic images from PET, CT and ultrasound, based on the principle of mutual information. Codes in MATLAB are being developed to improve on image quality, and the images from the PET/CT and US systems co-registered. The research on image fusion would not only be for diagnostic purposes but help in the better assessment of doses and tumour volumes for improved dose calculation algorithms in treatment planning.

Paper Number: 0335

THE ROLE OF HEALTH MANAGERS IN PROMOTING MEDICAL PHYSICIST IN AFRICA

Rebecca Nakatudde[1], Taofeeq A. Ige[2], Ahmed Ibn Seddik[3], Khaled El-Shahat[4]

[1]FAMPO, KAMPALA, Uganda, [2]FAMPO, ABUJA, Nigeria, [3]FAMPO, RABAT, Morocco, [4]FAMPO, CAIRO, Egypt

ABSTRACT

Background: The International Atomic Energy Agency (IAEA) has greatly improved the training of Medical Physicists and radiation scientists in most of the African countries. As defined in the IAEA BSS, the sole aim is to ensure safety and security of all radiation sources, to safeguard the radiation workers, members of the public, the environment and the patient when it comes to medical practices against accidental exposures. With this background, in Africa it is mandatory for each IAEA member state to have a regulatory body to regulate the use of ionising radiation in the existing practices in the entire country. In hospitals, with the support of the Health managers, it is the work of the Medical physicist to ensure that safety and protection is paramount. However, the regulators should over see the safety and protection of medical practices in addition to others elsewhere in the country at a national level. In the hospitals there is a need for collaboration among the Medical Physicists, hospital managers and the regulators for effective utilization of the use of ionizing radiation in medicine. This research aimed at analysing the current scenario and collaboration among regulators, Medical Physicists and hospital managers in the safe use of ionizing radiation in medical Practice in IAEA African member countries.

OBJECTIVES

To assess the current levels of participation and collaboration among regulators, Medical Physicists and hospital managers in the safe use of ionizing radiation in medical Practices in IAEA member states in Africa.

Invited Speaker

OPPORTUNITIES AND CHALLENGES FOR IMPLEMENTATION OF THE NEW INTERNATIONAL RADIATION BASIC SAFETY STANDARDS (BSS) IN AFRICA - ROLE OF THE MEDICAL PHYSICISTS

Maria del Rosario Pérez

World Health Organization, Department of Public Health and Environment, Radiation Programme. 20, avenue Appia, 1211 Geneva 27, Switzerland

The International Basic Safety Standards (BSS) for Protection against Ionizing Radiation and for the Safety of Radiation Sources are the benchmark for radiation safety requirements worldwide. The ultimate goal of radiation protection in health care is to control and minimize risks, while maximizing the benefits. While modern technology brings new and safer applications of radiation in medicine, incorrect or inappropriate handling can result in unnecessary and preventable risks for patients and staff. Medical physicists (MP) have a key role to strengthen radiation safety culture in health care and this is particularly relevant in Africa, where scaling-up the MP profession could significantly improve implementation of the BSS in the medical sector. This poses a major challenge in terms of MP education, training, recognition and staffing. At the same time, it offers new opportunities for a multi-sectoral approach and partnerships with a wide range of stakeholders at regional and global level. WHO offers its Global Initiative on Radiation Safety in Health Care Settings as a platform to support the BSS implementation in African countries in the framework of a global collaboration towards safer and appropriate use of radiation in medicine. Such integration can serve as a powerful catalyst for harmonization and benchmarking.

Invited Speaker

IAEA INITIATIVES ON EDUCATION AND TRAINING FOR MEDICAL RADIATION PHYSICISTS

Ahmed Meghzifene

International Atomic Energy Agency

The shortage of medical physicists, insufficient education and training, and lack of professional recognition were identified as the main issues to be addressed by the IAEA. To address these issues, the IAEA developed a series of integrated projects aiming specifically at promoting the essential role of medical physicists in health care, developing harmonized guidelines on dosimetry and quality assurance, and supporting education and training. A unique feature of the IAEA programme is the support it provides for implementation of guidelines and education programmes in Member States through its technical cooperation programme. The IAEA support for education and training includes published self-study material (Handbooks), detailed guidelines on clinical training in radiation oncology, X-ray diagnostic radiology and nuclear medicine, fellowships covering both short-term training and long-term (academic/clinical training abroad), setting-up national/regional education programmes, and organizing training courses and workshops focussed on specific topics for continuous professional development of medical physicists. In the last decade the IAEA has published several technical reports and guidance documents that are a useful resource for medical physics training. The IAEA has also developed a website called Human Health Campus to serve as a resource for health care professionals and students in radiation medicine. With the aim to support international harmonization of the practice of medical physics, the IAEA has just published the Human Health Report Series No. 25 on the roles and responsibilities of clinically qualified medical physicists and their education and clinical training requirements. The IAEA report has been endorsed by the IOMP and AAPM.

ICMP 2013

DAY 1

STFC

ICMP 2013

DAY 2, TRACK 1

STATE OF THE ART RADIOTHERAPY

Invited Speaker

FUTURE OF RADIOTHERAPY: BIOLOGICAL GUIDANCE

Robert Jeraj

University of Wisconsin Carbone Cancer Center, Madison, USA

A significant advance in radiation therapy is currently underway with the evolution from a population-based to a personalized patient-based dose prescription. Rapid developments in imaging, particularly adoption of molecular imaging, offer unprecedented opportunities for accurate characterization of tumor biology, as well as early assessment of treatment response. Accurate characterization of tumor biology enables effective selection of appropriate therapy or even a design of purposefully non-uniform tumor-specific treatment plans, tailored to the spatial distribution of biological properties of each patient's tumor. Early assessment of treatment response enables treatment adaptation, potentially intensifying or reducing the treatment dose to provide more efficacious and less toxic therapies. However, integration of imaging into therapeutic applications requires a high level of image quantification, well beyond what is currently required in diagnostic imaging applications.

Invited Speaker

THE FUTURE OF RADIOTHERAPY TREATMENT PLANNING

Steve Jiang

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Plan optimization for adaptive radiotherapy (ART) is a different problem from that for regular treatment planning given the availability of prior knowledge, i.e., the initial plan. The DVH curves of the initial plan can tell us the clinician-approved trade-offs among PTVs and OARs for this particular patient. Each DVH curve also represents the trade-offs among different dose-volume criteria for a PTV or OAR. The initial dose distribution has information on the clinician-preferred locations of hot/cold spots and the shape of iso-dose lines. We have developed two algorithms for DVH-guided automatic plan re-optimization, one based on a statistical moment method and the other based on a voxel-weighting optimization model. We have implemented all computational modules required for plan re-optimization on GPU to achieve high efficiency. A research platform (SCORE) for ART re-planning has been developed by integrating these modules into a Qt-based GUI. SCORE has been tested clinically for ART re-planning and proven to be a useful platform for clinical studies on ART. Our work on ART re-planning has also been extended to the development of a next-generation treatment planning system. The basic workflow for this system is as follows: 1) Upload patient CT and treatment protocol to a GPU cloud; 2) Automated contouring and planning guided by a reference plan selected from a library of previously approved and delivered plans; 3) Clinician to review and interactively fine-tune the contours and plan, if needed, using plan re-optimization GPU tools of real-time efficiency; 3) Download the plan, conduct QA, and then treat.

Paper Number: 0266

CTV-PTV MARGINS FOR USE WITH DAILY IMAGE-GUIDANCE.

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When image-guided radiotherapy (IGRT) is used to make daily positional corrections, the usual margin recipes, based on the standard deviations Σ and σ, cannot be used easily, since both Σ and σ of observed corrections are reduced by IGRT. The margin required will be determined by several remaining factors, including intra-fraction motion, inter- and intra-observer matching uncertainty, rotations and delineation uncertainties. Which of these dominates depends on treatment technique and site; some factors will not be known accurately. We describe a new methodology for combining estimates of these values into a single margin, to determine where we need to concentrate our measurement efforts.

For prostates, intra-fraction motion is the largest component of this margin. If one, for example using cone beam CT or TomoTherapy, images and applies moves before treatment, then re-images after treatment, the shift between images (denoted Δ) implicitly combines intra-fraction motion with intra-observer matching uncertainty. We derive a new expression for the margin required for this:

margin=2.5Σ/√2 +1.64((σ2+ σ2p)0.5-σp)/√2 +|μ| 2

where |μ| is the modulus of the mean of Δ. From measurements on 54 patients treated on TomoTherapy, μ= 0.0mm, 0.5mm, 0.5mm and 0.0° for LR, SI, AP and roll respectively. The corresponding standard deviations were Σ =1.1mm, 0.8mm, 0.8mm and 0.6° (systematic) and σ=1.3mm, 2.0mm, 2.2mm and 0.3° (random). This intra-fraction motion requires margins of 2.3mm in LR, 2.5mm in SI and 2.6mm in AP directions. The other uncertainties described above increase these margins, depending on the values estimated for the uncertainties.

Paper Number: 0284

EVALUATION OF AN INTRAFRACTION 4D CONE-BEAM CT (CBCT) IMAGING SYSTEM USING A 4D LUNG TUMOR PHANTOM DRIVEN BY MEASURED TUMOR MOTIONS FOR A LUNG CANCER PATIENT

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PURPOSE
We have evaluated intrafraction 4D cone-beam CT (CBCT) imaging during volumetric modulated arc therapy (VMAT) using a 4D lung tumor phantom driven by lung cancer motions that were measured by a 320-row CT.

METHODS
We measured lung tumor motions for a lung cancer patient under free-breathing conditions by using a 320-detector-row CT scanner (Aquilion ONE, Toshiba Medical Systems, Otawara, Japan) with a gantry rotation cycle time of 500 msec for a period of 20 sec. The resulting 4D lung positions were interpolated by spline functions for three orthogonal directions and the functions were fed into a controller of a 4D lung tumor phantom. During a single-arc stereotactic VMAT delivery for a lung tumor phantom, 4D CBCT projection data for the 4D phantom were acquired using an XVI 5.0 research unit (Elekta, Crawley, UK). The XVI unit calculated 10-phase binned 3D volume data based on the tumor positions on the projection images and the resulting 10-phase binned breathing trajectory was stored in the XVI unit. The 4D coordinates calculated by the XVI unit were compared to the 4D input data fed into the phantom controller.

RESULTS
We obtained a good agreement between the 4D input data and the trajectory data computed by the XVI unit.

CONCLUSION
We have confirmed that the XVI 5.0 research unit accurately calculated 10-phase binned 4D phantom positions during VMAT delivery.

Paper Number: 0221

ANALYSIS ON VOLUMETRIC AND DOSIMETRIC ACCURACY OF 4DCT FOR HIGH-PRECISION RADIOTHERAPY PLANNING USING 4D RESPIRATORY MOTION PHANTOM

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Purpose: To evaluate and compare the volumetric and dosimetric accuracy of 4DCT for high-precision radiotherapy planning using 4D programmable respiratory motion phantom

Materials and Methods: Five lung cancer patients who had undergone the treatment of high-precision radiotherapy and QUASAR respiratory motion phantom were used. The Philips 85cm Big-bore brilliance 16-slice CT scanner with bellow-belt system was used to generate the 4DCT data sets. The patients were subjected to free-breathing and 13 different 4D CT sets. The 4DCT was also obtained for moving phantom. Treatment planning was made using ADAC Pinnacle using Synergy-S linear accelerator for both phantom and patients for conformal, IMRT and stereotactic body radiotherapy. The treatment planning was made such as 0%-plan, 10%-plan, 20%-plan 30%-plan 40%-plan 50%-plan 60%-plan 70%-plan 80%-plan, and 90%-plan, AvgiP-plan, MIP-plan and FB-plan for both phantom and patients for comparison.

Results: In the phantom study, the volume differences were found to be 55%, 35%, 74% between FB vs MIP for GTV, OAR-1 and OAR-2 respectively. In the patient study, the volume differences were found to be 38% for GTV and 74%, for the spinal cord between FB vs MIP, respectively. All dosimetric variations between FB vs Avg-iP CT based plans were found to be 10-19.2% for target and OAR for both phantom and patients studies.

Conclusions: The volumetric and dosimetric variations between free-breathing and MIP images for both phantom and patient targets and organs at-risk were significant.

Paper Number: 0301

AUTOMATION AND OPTIMISATION OF CHECKING PROCEDURES IN RADIOTHERAPY USING DICOM-RT DATA AND FAILURE MODES & EFFECTS ANALYSIS

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The planning of radiotherapy treatments is a complex multistage procedure involving many staff groups. Mistakes can occur at any stage due to inattention, stress, fatigue, inadequate training or poorly-designed processes. At a minimum a mistake may require a treatment plan to be reworked and at worst can cause an adverse incident.

Checklists are commonly used as a control measure in healthcare but have been shown to be most effective when restricted to a small number of critical items. However the complex nature of radiotherapy planning often leads to lengthy paper checklists which continue to expand as additional failure modes are identified.

An alternative approach is presented in which the DICOM-RT Plan file for each patient treatment is electronically interrogated for consistency against a site-specific process model. The model incorporates the potential failure modes and their corresponding control measures using automation wherever possible. As well as reporting on the outcome of the automated checks, a restricted manual checklist is generated which includes any remaining key items requiring user assessment.

A further strength of this integrated approach is the ability to log the occurrence of specific errors, thereby generating a risk priority number (RPN) for each failure mode. The RPN also incorporates a severity-rating which is used to prioritise the manual checklists. This dynamic quality management tool thereby mitigates the risks of involuntary automaticity associated with static checklists.

Paper Number: 0019

DEVELOPMENT OF A FOUR-DIMENSIONAL MONTE CARLO DOSE CALCULATION SYSTEM FOR INTENSITY MODULATED DYNAMIC TUMOR-TRACKING IRRADIATION USING A GIMBALED X-RAY HEAD

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The purpose of this study was to develop a new dose calculation system for intensity modulated dynamic tumor-tracking (IMDTT) irradiation by gimbals mechanism in Vero4DRT.

In the dose measurement, a QUASAR platform phantom with water-equivalent phantom was used. EDR2 film was inserted at 5 cm depth between water-equivalent phantoms. Then, the QUASAR platform phantom was driven at a frequency of 0.25 Hz with amplitude of 15 mm in SI direction. The static IMRT and IMDTT irradiation were performed using a pyramid-shaped field with five segmental fields and a clinical field for a prostate IMRT case, respectively. The phantom position measured by a laser displacement gauge, rotational angles by the x-ray head, MUs, and the time were recorded in a log file.

In the simulation, 6-MV photon beam delivered by the Vero4DRT was simulated using EGSnrc. Then, a phase-space data at any angles was created from both the log file and the particle data under the MLC. Finally, both static IMRT and IMDTT were simulated by performing dose calculation under the target and the x-ray head position at each phase.

The averaged difference between the simulated and the measured doses was 2.4% using the pyramid field for IMDTT irradiation as well as static IMRT. Using the clinical IMRT field, the difference between the simulated and the measured doses for IMDTT irradiation was less than 3 % in the most area except the high dose gradient.

This study has demonstrated our proposed system has acceptable accuracy for IMDTT irradiation using the Vero4DRT.

Invited Speaker

THE FUTURE OF CLINICAL TRIAL RADIOTHERAPY QUALITY ASSURANCE

D Followill, M Knopp, J Galvin, TJ FitzGerald, J Michalski, M Rosen, F Laurie, E O'Meara, and S King

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The NCI's new National Clinical Trial Network (NCTN) Program starting in 2014, reduces the number of study groups from ten to five. The NCTN Program also requires a new combined Imaging and Radiation Oncology Core (IROC) service to provide a uniform trial QA program. The six existing clinical trial QA centers, Radiological Physics Center, Quality Assurance Review Center, RTOG QA Center, Image Guided Therapy Center, ACRIN Core Lab and CALGB Imaging Core Lab have combined to form IROC. The interdependencies between diagnostic imaging and radiation therapy (RT) will be synergized in IROC eliminating duplication of services and optimizing efficiency and effective workflows. A major strength of IROC will be the development of consistent standard operating procedures for all imaging and RT aspects of the NCTN and to facilitate a seamless flow of imaging and RT datasets across the network. IROC will provide scientific and technical expertise in both diagnostic imaging and RT to the entire NCTN Program capitalizing on existing infrastructure and expertise currently at the QA centers. IROC's organizational structure allows the delivery of an array of imaging and RT QA services including Site Qualification; Trial Design Support; Credentialing; Data Management and Case Review. IROC will work with the Global Harmonization Group to establish consistent QA processes for QA centers worldwide. The proposed IROC Group has hundreds of collective years of experience conducting clinical trial QA and fully understands the QA needs/dataflow requirements of clinical trials to maintain the highest quality data that will not obscure clinical trial outcomes.

This work was supported by PHS grants CA10953, CA21661, CA029511 and CA081647 awarded by NCI, DHHS.

Paper Number: 0056

CHARACTERIZATION OF AN IMPLANTABLE IN VIVO DOSIMETRIC PROBE BASED ON GALLIUM NITRIDE "GAN" RADIOLUMINESCENCE

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BACKGROUND

The purpose of this study is to assess the characteristics of GaN for external radiotherapy according to ESTRO and AAPM recommendations using 6MV photon energy.

MATERIALS AND METHODS

A PMMA homogenous phantom and an equivalent lung heterogeneous phantom were used for the testing. The dose measured using the GaN detector and the reference ionization chamber. The dose was calculated using Eclipse® treatment planning system. The photon beams calibrate using isocentric setup according to the following configuration: the active area of GaN was placed on the beam isocentre at SSD =95cm and depth at 5cm of PMMA (30 x 30 cm²).

We evaluated the correction factors: source-skin distance, field size, beam incidence, accessory, dose rate and cumulative dose. We studied also the response linearity, reproducibility and repeatability of measurements. The percentage depth dose and the transverse profiles were assessed. The Accuracy of measurements was estimated according to the gamma index. A statistical analysis was implemented using Wilcoxon signed rank test.

RESULTS AND DISCUSSION

The correction factors were in accordance with ESTRO and AAPM recommendations. The GaN-based dosimeter exhibited an excellent linear response with a good reproducibility and repeatability. Gamma index below the tolerance limit of (2mm, 2%) on the central beam axis and (5mm, 5%) on the field edges were achieved.

CONCLUSION

The GaN-based dosimeter has been tested in homogenous and heterogeneous phantoms, showing good accuracy of measurements in consistency with ionization chamber.

Paper Number: 0075

SETUP ACCURACY OF INTEGRATED 6 DEGREE-OF-FREEDOM ROBOTIC COUCHES IN STEREOTACTIC RADIOSURGERY RADIOTHERAPY SYSTEMS

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PURPOSE
To assess the accuracy of robotic patient positioning sub-systems (PPS) integrated within different radiation treatment-delivery-systems using common end-to-end phantom tests.

MATERIALS AND METHOD
In this study two PPS platforms were evaluated: Novalis ExacTrac®, and a novel Varian PerfectPitchTM prototype. Three phantoms were utilized for this work - a daily QA cube phantom with embedded fiducial markers, a spherical phantom designed commercially for stereotactic systems and an anthropomorphic phantom. Treatment plans were created for these phantoms on the vendor specific treatment planning systems, using the same prescription. Phantoms were placed on the PPS at their treatment positions using room lasers. Imaging systems deployed image fusion (x-ray stereo images or computed-tomography images) to compute shifts. Translational and rotational motions from 1-3 cm, 1-3 degree were purposefully induced and verified independently. Imaging subsystems were utilized to determine required shifts to reposition the phantoms to treatment positions and the phantoms were repositioned accordingly. Repeat images at the redirected positions provided residual translational and rotational errors. Dosimetric evaluation of the accuracy of pre- post relocations was carried out with a pin-point ion chamber.

RESULTS
Residual translational and rotational errors were within 0.1 cm and 0.1 degrees (Modal values). Errors were larger in magnitude for planning target volumes with large aspect ratios but within 0.2 cm and 0.2 degrees for the test conditions used.

CONCLUSION
A common methodology for the assessment of PPS accuracy has been developed. PPS accuracy assessed has demonstrated cross-platform equivalence in phantom positioning accuracy to within 0.2 cm and 0.2 degree.

ICMP 2013

DAY 2, TRACK 1

QUALITY AUDIT IN RADIOTHERAPY

Invited Speaker

IAEA QUALITY AUDITS IN RADIOTHERAPY AND SUPPORT TO NATIONAL DOSIMETRY AUDIT NETWORKS

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The IAEA has a long-standing history providing quality audits in radiotherapy and supporting national dosimetry audit networks. For 44 years of operation, the IAEA/WHO TLD postal dose audit service has checked the calibration of 10000 radiotherapy beams in 2000 centres in 130 countries. Several discrepancies in radiotherapy dosimetry have been discovered and rectified.

Another dosimetry audit programme developed at the IAEA uses the end-to-end approach, i.e. it assesses the entire workflow for conformal radiotherapy techniques, from patient data acquisition and treatment planning to dose delivery. It uses a semi-anthropomorphic phantom circulated among radiotherapy centres. Approximately 200 datasets for a beam/TPS algorithm combination have been collected in 60 radiotherapy centres in Europe. The experience of this programme indicates that proper attention must be paid to basic aspects of dosimetry and treatment planning.

The IAEA's comprehensive clinical audits by the Quality Assurance Team for Radiation Oncology (QUATRO) assess overall radiation oncology practices in radiotherapy centres. To-date QUATRO has conducted over 70 audits on request, in radiotherapy centres of Central and Eastern Europe, Asia, Africa, and Latin America. QUATRO audits have contributed to improvements at audited centres, but also identified common issues that are being addressed at the national level, and internationally.

The IAEA has supported the establishment of several national audit groups for radiotherapy dosimetry and assisted in the development of methodology for a range of quality audit levels, from basic to complex. The network of national audit groups contributes to improving the consistency in dosimetry in radiotherapy centres world-wide.

Invited Speaker

CREDENTIALING FOR CLINICAL TRIALS IN RADIOTHERAPY

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The Radiological Physics Center (RPC), for 45 years, has assured NCI and the cooperative groups that institutions participating in multi-institutional trials can be expected to deliver radiation treatments that are clinically comparable to those delivered by other institutions. To accomplish this, the RPC has implemented a QA program that includes remote and on-site audits, patient case reviews, proton therapy approvals and protocol specific credentialing. Credentialing serves as an educational tool to improve the understanding of the protocol and as a demonstration of ability. The introduction of advanced technology trials has prompted clinical trial groups to require participating institutions and personnel to become credentialed, to assure their familiarity and capability with techniques such as IMRT, SBRT, proton therapy, IGRT and brachytherapy. Credentialing activities can include; facility questionnaires to evaluate an institution's resources and capabilities, treatment planning benchmarks to demonstrate planning ability, knowledge assessments to verify understanding of the protocol requirements, electronic data submission capability, end-to-end phantom irradiation studies to demonstrate accurate dose delivery for new technologies and pre-treatment patient case reviews to verify protocol compliance. Credentialing techniques must be efficient but effective since their goal is to minimize deviations so trials are completed with the most consistent and accurate data with the maximum number of evaluable patients. The benefit of the additional effort expended by institutions in the credentialing process helps to ensure that the clinical trial radiotherapy treatments are accurate and comparable. These QA efforts result in trial outcomes that have not been obscured by uncertainty in the radiotherapy data.

This work was supported by PHS grants CA10953 and CA081647 awarded by NCI, DHHS.

Paper Number: 0251

DOSIMETRY AUDIT OF RADIOTHERAPY TREATMENT PLANNING SYSTEMS

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INTRODUCTION

In the radiotherapy Treatment Planning Systems (TPS) various calculation algorithms are used. The accuracy of dose calculations has to be verified. A heterogeneous cubic-shape phantom has been designed within a Coordinated Research Project of the IAEA.

MATERIALS AND METHODS:

The heterogeneous phantom was developed in the frame of IAEA Coordinated Research Project. The phantom consists of frame made with polystyrene and bone or lung inhomogeneity slabs. Special inserts allow to position TLD capsules within the polystyrene below the bone or lung material and also within the lung equivalent material. There are also inserts for positioning ionization chamber and films. These enable comparisons of the doses calculated by TPSs for specific treatment. The comparisons were performed for a number of various TPS and for a number of various linear accelerators in radiotherapy departments in Poland.

RESULTS

Seven Polish radiotherapy centers (of 28 in total) were audited. Six different TPSs and eleven calculation algorithms were examined. Generally most of the results from TLD and ionizing chamber were within 5% tolerance. Differences between doses calculated in TPSs and measured with TLD did not exceed 4% for bone and polystyrene equivalent materials. Under the lung equivalent material, on the beam axis the differences were lower than 5% whereas inside off the beam axis – in some cases were around 7%.

CONCLUSIONS

The measurements allow to the detect limitations of TPS calculation algorithms. The audits performed with the use of heterogeneous phantom seem to be an effective tool for detecting errors in radiotherapy procedures.

Paper Number: 0083

DEVELOPMENT OF A UK DOSIMETRY AUDIT FOR HDR/PDR BRACHYTHERAPY

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PURPOSE

To report on the development of the first comprehensive dosimetry audit of HDR/PDR brachytherapy, part-funded by IPEM and RTTQA Interlace trial, and supported by NPL. External audit in brachytherapy is an underdeveloped quality assurance process. Worldwide, only seven audits have been reported, limited to point dose or source strength, and have omitted treatment applicator dosimetry.

METHOD

The audit uses two complementary phantoms for: (1) high accuracy measurement of point dose using alanine from a series of source dwells in a straight plastic catheter, (2) measurement of dose distribution around clinical cervix applicators using film and comparison to treatment planning system calculations. Phantom (1) is constructed from Solid Water, within a Perspex scatter box, and contains a central source catheter with concentric alanine measurement points at 20 mm, equally spaced around the source. Phantom (2) consists of a Solid Water frame which precisely and rigidly holds the applicator and four films, contained within a full scatter water tank. The latter constitutes a 'system test' including applicator CT reconstruction.

RESULTS

Alanine and film dosimetry systems have been calibrated and validated for use in brachytherapy applications for both Ir-192 and Co-60 sources. Pilot audits have been completed demonstrating the suitability of the phantom designs. Comparison of planned and measured dose distribution had a mean gamma passing rates of 98.6% using criteria of 3% local normalisation and 3 mm distance to agreement.

CONCLUSION

A brachytherapy dosimetry audit system has been developed that can provide a unique and comprehensive quality assurance assessment.

Paper Number: 0300

COMPARISON OF DAY-0 ULTRASOUND REAL-TIME DOSIMETRY WITH DAY 0 AND DAY 30 CT-BASED DOSIMETRY FOR PERMANENT PROSTATE IMPLANTS USING 125I SINGLE SEEDS

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INTRODUCTION

Day 30 CT-based dosimetry is the gold standard for final verification of prostate permanent implantation quality. This study will investigate whether clinically significant changes in the dose to the prostate and critical adjacent structures occur between Day 0(CT-0) and 30 (CT-30). This is achieved using CT-based Dosimetry. Differences between Day-0 Ultrasound (US-I) and CT-0 are also analysed.

METHODS AND MATERIALS

Dosimetry for 50 patients with permanent prostate implants using 125I seeds was evaluated using intraoperative US Day 0, CT imaging Day 0 and Day 30.

The dose received by 90% of the target volume (prostate D90), percentage of volume receiving 100%, 150% and 200% of prescribed dose (prostate V100, V150, V200), urethra D30 and D10, and rectal V2cc dose and prostate volume were analysed using Paired Student T-test. Differences were regarded as statistically significant at $p < 0.05$.

RESULTS AND CONCLUSION

Initial results show significant differences between the CT-0 and CT-30 dosimetric parameters analysed. D90, V150 and V200 prostate and V2cc rectum mean values were higher for CT-30 than CT-0 and US-I. US-I and CT-0 urethral and rectal dosimetric parameters showed no significant differences.

Early verification of dosimetric parameters using CT-0 is desirable as sub-standard implants can be identified. It is more convenient for the patient and allows verification of urethra dosimetry.

Based on these initial results, CT-0 cannot replace CT-30 as the gold standard for final verification of prostate permanent implantation quality.

Paper Number: 0183

SINGLE STAGE REAL TIME LDR PROSTATE BRACHYTHERAPY - CLASS SOLUTION DEVELOPMENT

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AIM

Development of class solutions for ordering I-125 seeds without the need for a pre-implant, intraoperative volume study. Elimination of the initial volume study under general anaesthetics significantly improves patient experience. Additionally, this approach reduces the overall cost of the treatment as only one theatre session is required. The class solution approach removes the need for seed cutting in theatre, which may reduce operator finger doses, and physicist time required is also reduced as a preliminary plan is not produced for each patient.

MATERIAL AND METHODS

The class solutions are based on the prostate dimensions measured in outpatients using a minimally invasive transrectal ultrasound. They are developed using prostate models with variable dimensions artificially created for this purpose in Varian's Variseed 8.0 software. All class solutions were verified against past patient prostate volumes (123 cases). Comparisons were made between both scanning techniques to confirm the differences in measurements were minimal.

RESULTS

The initial study validated the use of one class solution for 7 patients with prostate volumes 30-35cc and lengths 4-4.5cm. For all patients, more seeds were required than the class solution predicted. However, the difference in seeds was small (range=0-6 mean=3.7) and within the usual number of additional loose seeds ordered for live planning. Initial comparisons between the two scanning methods has shown good agreement, however further intercomparisons are needed before clinical implementation.

CONCLUSION

A class solution based on outpatient volume study may be sufficient for seed ordering when using real time planning.

Paper Number: 0283

CLINICAL LDR PROSTATE BRACHYTHERAPY UNCERTAINTIES FROM SEED CONSTRUCTION PARAMETERS

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While several uncertainty sources have been reviewed for LDR prostate brachytherapy, the effect of seed construction uncertainties on clinical dosimetry has not been assessed.

A standard uncertainties map was calculated for an 125I LDR seed assuming uniform probability distributions of construction parameter uncertainties: xi±axi. Let DR/SK (xi) be a point in the 3D matrix of dose rate per unit air kerma strength. Assuming DR/SK is approximately linear and no correlation exists between xi, standard uncertainty can be calculated using the law of uncertainty propagation.

MC simulations were performed to obtain the DR/SK distribution around the nominal seed design as well as designs with xi equal to xi-axi or xi+axi. This allowed for the finite difference approximations of partial derivatives for propagation, and hence the calculation of a total standard uncertainty matrix. The superposition principle was used with information from a patient plan dicom-RT export to calculate a 3D clinical dosimetry uncertainty matrix.

The nominal, relative, dose distribution was compared to worst case scenarios of all seeds in the implant exhibiting uncertainties of plus or minus 1 standard uncertainty.

While single seed uncertainty at points near the longitudinal axis is comparable to NIST SK calibration uncertainty, due to the increased number of implanted seeds clinical dosimetry is affected <1% at the PTV surface and <2% within the PTV.

ACKNOWLEDGEMENT

This research has been co-financed by the European Union (ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the NSRF - Research Funding Program: Heracleitus II.

Paper Number: 0165

MODELING A SCATTERED RADIATION FROM MLCS FOR IN-AIR OUTPUT FACTORS FOR FF AND FFF PHOTON BEAMS

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Scattered radiation from multi-leaf collimators (MLCs) is no longer negligible for calculating in-air output ratio, Sc for small and irregular fields often used in intensity-modulated radiation therapy (IMRT). An extra-focal source model for scattered radiation from MLCs, namely MLC scatter source, has been developed to improve the accuracy of the Sc calculation with and without flattening filter (FF). A conventional dual-source model was made by using Sc data that were measured for collimator-defined fields of Varian TrueBeamTM. We used two defferent beams : 6 MV with and without FF. Then, an MLC scatter source at the center of the MLC position of the linear accelerator was assumed in the model. The MLC scatter source model consisted of two Gaussian functions of which parameters were iteratively optimized against the Sc data measured for different MLC fields with fixed collimator sizes. To evaluate the effectiveness of the developed source model, measurements were made for various MLC-defined irregular or square fields. The calculated Sc data by using (1) the developed source model and (2) the conventional dual source model were compared with the measured data.The mean discrepancy between the measured Sc and calculated Sc from the developed source model was 0.07 0.19%, while one from the conventional source model was 0.74 0.35%. The developed MLC scatter source model in conjunction with the dual source model could improve the accuracy of the Sc calculation in IMRT fields with and without FF.

ICMP 2013

DAY 2, TRACK 1

QUALITY CONTROL IN RADIOTHERAPY

Invited Speaker

PATIENT-SPECIFIC QUALITY CONTROL BY MEANS OF 3D IN VIVO DOSIMETRY

B. Mijnheer

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Patient-specific quality control (QC) plays an important role in the total chain of verification procedures in a radiotherapy department. Generally patient-specific QC is performed by means of pre-treatment dose measurements using a homogeneous slab phantom, i.e. patient-specific anatomic information and tissue inhomogeneities are not taken into account. In our department patient-specific 3D in vivo dosimetry is used for all curative treatments, mostly IMRT and VMAT, as well as for all palliative treatments, by applying a fast and simple back-projection EPID dosimetry algorithm. By optimizing the software and the workflow it was possible to perform fully automated 3D in vivo dosimetry for all patient treatments. The rationale for 3D in vivo measurements is to provide an accurate and independent verification of the overall treatment procedure. It will enable the identification of potential errors in dose calculation, data transfer, dose delivery, patient setup and changes in patient anatomy. In this presentation it will be shown that 3D in vivo dosimetry, in combination with in-room imaging, is a fast and accurate tool for patient-specific QC of advanced radiotherapy techniques. EPID-based 3D in vivo dosimetry provides clinically more useful information and is less time consuming than patient-specific pre-treatment QC. In addition to accurate 3D dose verification, 3D in vivo EPID-based dosimetry will also detect major errors in the dose received by individual patients. It is therefore recommended that all treatments with curative intent should be verified through 3D in vivo dose measurements in combination with some kind of pre-treatment check.

Invited Speaker

CAN WE IMPROVE SAFETY AND QUALITY OF SOPHISTICATED MODERN RADIOTHERAPY PLANNING AND DELIVERY?

Benedick A. Fraass, Ph.D.

Department of Radiation Oncology, Cedars-Sinai Medical Center, Los Angeles, CA, USA

The complexity and precision of sophisticated modern radiotherapy treatment planning and delivery techniques (e.g. IMRT, IGRT, VMAT, SBRT) and modern computer-controlled treatment delivery systems continue to increase as we strive to improve the therapeutic ratio for radiotherapy treatment. It is clear, however, that our efforts to improve safety and quality of patient treatments must re-double, given the potential for serious patient injury if major problems occur. It is also clear, however, that the old quality assurance (QA) methods of the past are too labor-intensive and too limited to address all problems which can arise in the current radiotherapy planning and delivery process. We must make use of techniques relatively new to RT, including tools from systems engineering which include considerations of risk, frequency, severity, and detectability for failures throughout the planning and delivery process, rather than tied to specific machines or activities. Groups on both sides of the Atlantic are working to develop this new methodology (AAPM TG-100, ACCIRAD), as well as many individual institutions. This presentation will discuss the new risk-oriented strategies as well as our older QA methods, within the context of our highly complex IGRT-IMRT-VMAT type radiotherapy treatment paradigms, and will look for the most effective ways to improve our ability to delivery safe and effective treatment to our patients.

Invited Speaker

QUALITY ASSURANCE FOR IMRT AND VMAT

Philip Mayles

Clatterbridge Cancer Centre, Liverpool, UK

The time taken for quality control has been a limiting factor in the roll out of IMRT in the UK and elsewhere. There is a growing realisation that IMRT can offer reduced toxicity and with VMAT this can be accompanied by a reduction in treatment time. Quality systems should therefore minimise the time taken to achieve assurance of correct patient treatment, while not adopting a careless attitude to patient safety. In the early days of IMRT individual patient QC was carried out with film and ionisation chamber measurements and these could take several hours per patient. Using modern electronic devices (including the portal imaging system) measurements can be carried out in the time it takes to deliver a patient treatment. Many centres have adopted gamma analysis as the ultimate determinant of plan acceptability, but it is important also to consider the mean dose to the target. However, such measurements may not be the most efficient way to ensure treatment accuracy. The principal issues are: that the plan selected is the plan calculated by the TPS, that the plan can be accurately delivered by the treatment machine, and that the target volume is in the planned relation to the linac. Some are advocating using an independent dose calculation method to replace measurement on the treatment machine but this approach provides only limited assurance that the treatment machine will deliver the planned treatment. If more emphasis is placed on the routine quality control of the treatment machine individual patient measurements can be safely reduced.

Paper Number: 0119

INTENSITY-MODULATED RADIATION THERAPY QUALITY ASSURANCE WITH A NOVEL THREE-DIMENSIONAL RADIOCHROMIC FILM STACK DOSIMETER

Travis McCaw, John Micka, Larry DeWerd

University of Wisconsin, Madison, WI, USA

Delivery quality assurance (DQA) of intensity-modulated radiation therapy (IMRT) procedures is traditionally performed with planar measurements of the per-beam or composite dose distributions. However, advancements in conformal radiation therapy techniques, such as volumetric modulated arc therapy, have increased the need for three-dimensional (3D) dose verification measurements. Existing 3D dosimeters require specialized readout techniques, such as MRI or optical CT. A novel 3D radiochromic film stack dosimeter (FSD), an extension of planar film dosimetry, has been developed and characterized for measurement of therapeutic photon beam energies. The purpose of this work was to investigate the potential of the FSD for IMRT DQA. Five-field and seven-field step-and-shoot stereotactic body radiation therapy procedures were prepared using the CT dataset of a lung cancer patient. Two measurements of the delivered dose from each plan were taken with the FSD. The dose from the seven-field plan was also measured using TLD microcubes for comparison. The duplicate FSD measurements agreed within an overall measurement uncertainty of 2.5% (k=2). Using gamma criteria of 3% and 3 mm, the five-field-plan and seven-field-plan measurements agreed with the calculated distributions with passing rates greater than 99% and 97%, respectively. The doses at points within the measured FSD distribution that did not satisfy the gamma criteria were verified by the TLD measurements, demonstrating the ability of the FSD to accurately identify delivery errors. The FSD is shown to be a reliable dosimeter for IMRT DQA, providing a 3D dosimeter that could readily be incorporated into an existing film dosimetry protocol.

Paper Number: **0322**

AUTOMATION OF THE PICKET FENCE TEST ON VARIAN TRUEBEAM USING IN-HOUSE SOFTWARE AND PORTAL IMAGING.

Adam Agnew, Conor McGarry, Christina Agnew

Northern Ireland Cancer Centre, Belfast, UK

PURPOSE

An in-house program was developed to automate analysis of portal images acquired following delivery of a RapidArc QC test suite. The accuracy of MLC position during rotational delivery was investigated over 8 months.

METHOD

VMAT tests including the RapidArc picket fence (during rotational delivery) and a static picket fence (at fixed gantry angles) were delivered to an electronic portal imaging device (EPID) on two Varian TrueBeam linear accelerators (linacs). The RapidArc picket fence and static picket fence (at alternating cardinal gantry angles) were carried out daily. In-house software was developed in MATLAB to automate analysis and evaluate the 600 acquired images. The software calculates the separation and deviation of each leaf pair from its calibrated position. Leaf pair positions were further analysed using Varian trajectory log files.

RESULTS

For the picket fence test, mean deviations of 0.01±0.06 mm and -0.07±0.15 mm were observed for separation and offset respectively (±1SD). Two systematic displacements were observed on single MLCs that led to the replacement of the t-nuts. The software identified leaf positioning errors up to 1 mm in magnitude, which was undetectable following trajectory log analysis.

CONCLUSION

The in-house developed software allowed the RapidArc QC test suite to be incorporated into a linac-specific QC system, permitting the reduction of patient-specific QC. This analysis found MLC faults that log file analysis could not detect.

Paper Number: 0193

IMPLEMENTATION OF AN AUTOMATED SYSTEM FOR THE QUALITY ASSURANCE OF LINEAR ACCELERATORS USING ELECTRONIC PORTAL IMAGING DEVICES

Aaron Huckle, Jonathan Sykes, Isobel Bond, Philip Rixham, Samir Dawood, Gillian Ward, Joshua Mason, Steve Weston

St. James Institute of Oncology, Leeds Teaching Hospitals NHS Trust, Leeds, UK

A large amount of linear accelerator resource is used to perform quality assurance (QA) using conventional techniques and tools. The widespread availability of electronic portal imaging devices (EPIDs) makes possible efficient QA from megavoltage images. Utilising rapid, frequent, automatic QA of linacs their performance can be monitored on a daily basis using minimal linear accelerator clinical availability.

The implementation of automated quality assurance checks for daily monitoring of linac performance has been investigated using EPIDs. The aim was to develop a pathway whereby existing integrated network and imaging infrastructure could be used to fully automate the image processing and reporting stages with minimal user intervention.

IMRT prescriptions were written to automate beam delivery of open and wedged 20x20cm square fields, and opposing collimator angles on an Elekta Synergy linear accelerator. An IviewGT image of each segment was auto-forwarded to an image sorting program which allocated images to analysis modules based on a series of simple rules. The analysis performed on each image included flatness, symmetry, wedge factor, beam quality, output, and leaf calibration. The results were automatically stored in a mySQL database where they were interrogated to display the results.

The full data pathway from acquiring the images using the Elekta iViewGT imaging panel to recording processed results in the SQL database has been tested and shown to be clinically feasible. Preliminary timing audits and data analysis demonstrate the net clinical benefit.

Paper Number: 0115

COMMISSIONING OF FFF FOR THE ELEKTA AGILITY

Sarah Kane[1], Daniel Sullivan[2], Neil Richmond[1], Christopher Walker[1]

[1]The James Cook University Hospital, Middlesbrough, UK, [2]Cumberland Infirmary, Carlisle, UK

Medical linear accelerators have traditionally been fitted with flattening filters in the beam line to compensate for the forward peaked nature of photon production. However, flattening filter free (FFF) beams have recently become a viable option for external beam radiotherapy. The use of FFF beams has several benefits such as reduction of head scatter and increased dose rate. The radiotherapy department at the James Cook University Hospital undertook commissioning measurements for a FFF beam on an Elekta linac with Agility MLC head.

MEASUREMENTS

Measurements were made in a water tank of beam profiles and percentage depth dose curves (PDDs) for the 6MV FFF beam for a variety of field sizes and depths. Beam models (pencil beam and collapsed cone) were generated by Nucletron for Masterplan using this data. A comparison of these models with the original measured data was performed by simulating the beam geometries in the planning system.

RESULTS

All measured beam profiles agreed with the beam model within 2% in the central 80% of the field and within 1.5mm in the penumbral region. The measured PDD curves agreed with the beam model to within 2% for the pencil beam model from dmax to 35cm deep. For the collapsed cone model agreement was within 2% from dmax to 21cm deep after which greater discrepancies were found.

CONCLUSIONS

The beam models gave good agreement with the measured data for the scenarios studied although further comparisons are required before clinical use.

Paper Number: 0190

ABSOLUTE DOSE CALIBRATION FOR OPERATION OF THE FLATTENING-FILTER FREE MODE OF A TRUEBEAM LINAC

John Frame, Kirstie Brown, Martin Ford

Beatson West of Scotland Cancer Centre, Glasgow, UK

The Beatson West of Scotland Cancer Centre has recently installed and commissioned two Varian Truebeam Linacs, both of which are capable of operating in flattening-filter free (FFF) mode. FFF allows much higher dose rates than usual to be achieved, which is desirable when performing stereotactic radiosurgery due to the reduction in treatment delivery time. Removing the flattening filter is problematic in terms of dosimetric calibration, however, due to the change in energy spectrum of the beam. As a result, calibration factors as currently supplied by the NPL may not be valid for the transfer of absolute dose calibration from the primary standard in the UK.

Measurements of FFF outputs were made using Alanine dosimeters, supplied by the NPL, with initial output calibration of the FFF beam performed according to the current UK photon Code of Practice. Additionally, Gafchromic EBT2 film was employed as an independent measurement of dose accuracy. Dose measured using Alanine was approximately 2% lower than that measured with an ionisation chamber, with Gafchromic film measurements in good agreement with the dose measured by Alanine.

In conclusion, using the current UK Code of Practice to calibrate FFF output appears to lead to an overestimate of delivered dose. Using the NPL Alanine dosimetry service allows the production of an additional correction factor to be included in FFF absolute dose calibrations to account for this change.

Paper Number: 0302

COMPARISON OF THE COMMISSIONING DATA FOR CIRCULAR COLLIMATORS OF THE UK'S FIRST THREE NOVALIS TX STEREOTACTIC RADIOSURGERY LINACS

Martyn Gilmore[1], Linda Carruthers[2], Phill Cooper[3], Andiappa Sankar[2], Alison Scott[1]

[1]Clatterbridge Cancer Centre, Wirral, UK, [2]Edinburgh Cancer Centre, Edinburgh, UK, [3]The Christie Hospital, Manchester, UK

Novalis TX Linacs have mountable Collimators to deliver precise, circular radiation fields of diameter 4-15mm. Characterising such small-fields represents a significant technical challenge due to detector size and the lack of lateral electronic equilibrium for very small fields (Scott et al 2008). Analysis has been carried out on the independent commissioning data of the three UK Novalis centres for both the standard and SRS modes.

Measurements were made using the SRS diode at the Christie and Edinburgh, whilst Clatterbridge used an electron diode to measure the standard data and the SRS diode for the SRS. The Christie used a Pinpoint chamber as an intermediary between the collimators and the 10x10 cm field for the Output Factor (OF) measurements.

Profiles and Depth Doses were compared using the Venselaar criteria (Venselaar et al, 2001). Brainlab's iPLAN software requires OF acquired under isocentric conditions but referenced to a 10x10cm field at 100cm SSD. A direct comparison of the ratio between each collimator and the largest available (15mm) was made as well as comparing the absolute outputs.

DD and Profiles showed excellent agreement between the centres, with some small discrepancy due to the different detectors used. OF ratios showed agreement to within 1 % between Clatterbridge the other 2 centres. For absolute output factors, Edinburgh data agrees with Clatterbridge's (within 2 %) but the agreement with the Christie's data is poorer (within 3%) probably due to the different chambers and intercomparison factors applied.

We therefore have confidence in the quality of the data obtained.

ICMP 2013

DAY 2, TRACK 2

RADIATION PROTECTION LEGISLATION AND STANDARDS

Invited Speaker

RADIATION, RISK AND REGULATION; ACHIEVING THE RIGHT BALANCE

Dr Penelope Allisy-Roberts OBE (retired)

Our world is full of life-threatening hazards and we adapt our responses to danger almost without thought – mostly having learned from others or from personal experience. Fortunately in the field of ionizing radiation, there is plenty of experience and advice about what and how much risk we face in our daily lives. More importantly is the advice on how to minimize the occurrence of early effects and the probability of long-term effects. This advice started with the personal experience of the early radiation martyrs, such as Major John Hall-Edwards, a surgeon practising in Birmingham at the turn of the last century. His book of practical advice could almost be taken today as a set of Local Rules in any radiology department - the basic tenets of radiation protection hold as well today as they did 100 years ago. Each of us has the responsibility of ensuring that our diagnostic and therapeutic uses of ionizing radiation achieve what is required without causing harm to the patient, ourselves or others. The HSE and others worked hard to ensure that the last two major sets of IR regulations in 1985 and in 1999, and indeed IR(ME)R in 2000, achieved this without hindering the advances needed in medicine. How they did this will be discussed in the light of the radiation risk of the medical use of ionizing radiation and consequently the same standards, when applied for the next set of regulations due in about 2016, should enable us to continue to practise safely.

Invited Speaker

TREATMENT PLANNING FOR SPOT SCANNED PROTON THERAPY. THE NEXT STEPS

Tony Lomax

Centre for Proton Therapy, Paul Scherrer Institute, Villigen-PSI

There is a rapidly growing interest in proton therapy, particularly in spot scanned proton therapy. Although there are still only a handful of proton facilities actually using spot scanning clinically, it is widely recognized that the flexibility of scanning, and its natural extension, Intensity Modulated Proton Therapy (IMPT), means that it will become the dominant modality for delivering proton therapy in the near future. However, although extremely flexible and powerful, spot scanned proton therapy is also extremely sensitive to both anatomical changes of the patient and organ motions. In order to be able to best deal with both these issues, sophisticated treatment planning methods and strategies need to be developed. In this presentation, after introducing the basic concepts of proton therapy and treatment planning for spot scanning, we will look at three such treatment planning methods. First, we will introduce the concept of 'anatomically robust' planning, by which treatments that are robust to potential anatomical changes can be constructed. Second, we will make the case for highly efficient calculation systems and treatment planning workflows to move towards 'plan-of-the-day' strategies, combining both a-priori adaptions of the treatment based on daily imaging and a-postori dose reconstructions based on delivered log files. Third, we will look into methods for accurate four dimensional calculations and dose reconstructions for planning and optimizing the treatment of mobile tumours. In summary, there is still much work to be done in the treatment planning of spot scanned proton therapy. But only through such developments can the true potential of this exciting treatment modality be fully exploited.

Invited Speaker

MONITORING FINGER DOSES FOR HANDLING OF RADIOPHARMACEUTICALS

Filip Vanhavere

SCK•CEN, Belgian Nuclear Research Centre

One of the goals of the European ORAMED project aimed at enlarging the general knowledge of hand doses delivered to nuclear medicine (NM) staff when handling most frequently used radiopharmaceuticals, i.e. those labeled with 99mTc and 18F for diagnostics procedures, and those labeled with 90Y for therapy procedures. An extensive measurement program including 124 workers from 32 NM departments in Europe was performed. Dose distribution across the hand was obtained by measuring skin dose at 11 points of each hand using appropriate thermoluminescence dosemeters attached on gloves. Furthermore, more than 200 Monte Carlo simulations were performed to better understand the parameters influencing the hand dose. Guidelines were elaborated by merging the statistically analyzed results of measurements with those from the simulations. The most exposed positions are the tip of the index finger and the thumb of the non dominant hand. For routine monitoring, the recommended dosemeter position is the index finger base of the non-dominant hand with the detector in palmar direction. Nevertheless, the maximum skin dose is underestimated on average by a factor of 6 at this position. Shielding of vials and syringes is essential for dose reduction but not a guarantee for low exposures. All tools increasing the distance between the hands/fingers and the source are very effective for dose reduction. Working fast is not sufficient, shielding or increasing distance are more effective. This study highlights the necessity to monitor extremity exposure in NM. The annual skin dose limit of 500 mSv was exceeded by approximately 20% of the workers.

Paper Number: 0006

ENERGY SPECTRA AND TRANSMISSION CHARACTERISTICS OF SCATTERED RADIATION FROM COMPUTED TOMOGRAPHY: A MONTE CARLO STUDY

David Platten

Northampton General Hospital, Northampton, UK

Current data used to calculate transmission of scattered radiation from computed tomography (CT) are based on transmission of primary beam CT energy spectra. This study aims to calculate the energy spectra of CT scatter, and then determine the transmission of these spectra through lead.

The easy particle propagation (Epp) user code for the EGSnrc Monte Carlo system has been used to expose an ICRP 110 male reference phantom to simulated primary CT x-ray beams. Two peak kilovoltage settings have been used (120, 140kVp) at two beam filtrations (6.8, 9.8mm aluminium). The energy spectra of scattered x-rays leaving the simulation geometry have been calculated for each primary beam. These scatter spectra were then used as the broad-beam x-ray source in simulations to calculate transmission through seventeen thicknesses of lead (0.00 to 3.50mm). The transmission data was fitted to obtain α, β and γ coefficients for each scatter spectra.

The mean energy of each scattered spectrum was lower than the primary beam mean energy by up to 14keV. The scattered spectra transmission through lead was lower than that calculated using existing data for all beams at every lead thickness. For 2.5mm of lead the ratio of scatter spectrum transmission to primary spectrum transmission was as low as 0.32.

This work has shown that the transmission of scatter radiation through lead from CT is lower than that calculated with currently available data. Using the data from this work may result in less lead shielding being required for CT installations.

Paper Number: 0130

DOSE LEVELS AROUND PATIENTS IN INTERVENTIONAL RADIOLOGY CAN BE PREDICTED FROM SCATTERED RADIATION SPECTRA.

David Sutton

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PURPOSE

To show how simulation of the scattered x-ray spectra can be used to predict the variation of doses to staff around a patient, and thus assist optimisation of staff doses in interventional radiology.

METHOD

An 85 kV x-ray beam with 3mm Aluminium filtration plus 0.125 mm added copper was modelled incident on an elliptical cylindrical water phantom using MCNP5. The cylinder was 41 cm long and had semi major and minor axes of 15 cm and 12 cm respectively. Detectors (0.5cc air) were placed 1m from the centre of the phantom at 0°, 30°, 60°, 90°, 120° and 150°. Scatter fluence spectra, expressed in terms of mm-2 (Gycm2 in the primary beam)-1, were determined at each scattering angle. Interpolated values of (μen/ρ) were then used to transform the fluence spectra into air kerma (Ka) spectra (in units of μGy(Gycm2)-1). These spectra were folded with coefficients from ICRP74 and 116 to generate spectra of absorbed dose to the eye (DT,AP), and the operational quantities personal and ambient dose equivalent (Hp(10), Hp(07) & H*(10)). Integration of the spectra allows determination of the dose quantities as a function angular position and the KAP incident on a patient.

RESULTS

Typical results are that Ka at 1m varies from 1.6 μGy(Gycm2)-1 at 30° to the primary beam to 10 μGy(Gycm2)-1 at 150°. This corresponds to undercouch and overcouch irradiation geometries. Absorbed dose to the eye, a quantity of much current interest, varies between 2.2 and 13.4 μGy(Gycm2)-1 in the same geometries.

Paper Number: 0048

NEW CHALLENGES IN MOVING TOWARD NANO-SIZED LEAD-FREE RADIATION SHIELDS

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Over the past decades nanotechnology has enabled us to create a wide variety of life-changing products. This technology is also currently used for production of multipurpose radiation shields. Since the discovery of x-rays and radioactivity, flexible lead-based radiation shields have been widely used in radiology departments. However, recently there has been a great deal of concern expressed about the toxicity of lead. In this light, production of environmentally-friendly lead-free radiation shields with less weight compared to conventional lead-based shields is a challenging issue in diagnostic radiology and nuclear medicine. We have previously produced tungsten-tin-filled polymers with appropriate radiation attenuation properties. Recently, we have focused on the radiation shielding properties of nano-sized shielding materials. Flexible sheets of WO3 in a poly vinyl chloride (EPVC) polymeric matrix were produced in our laboratory. In this experiment, WO3 nanoparticles with grain size ranged 20-100 nm (+99% purity) and WO3 micro particles with average particle size <20 μm (+99% purity) were incorporated in a EPVC polymeric matrix in proportions of 20%, 50% and 60% of the total mass of each sample. Findings obtained in this study showed that the nano-structured WO3/PVC samples present a significant greater potential in absorbing low energy X-ray photons compared to that of the samples produced with microstructured WO3/PVC. Our experiments showed that the smaller size of the nano-structured WO3 particles can guarantee a better radiation shielding property. In this paper new challenges in moving to nano-sized lead-free radiation shields are discussed.

Paper Number: 0242

CT-FLUOROSCOPY: A CASE STUDY FOR THE NECESSITY OF A MEDICAL PHYSICS APPROACH TO BIOETHICS

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Servico de Fisica Medica do Instituto Portugues de Oncologia do Porto Francisco Gentil, EPE, Porto, Portugal

CT-Fluoroscopy is a relatively recent development in computed tomography (CT), allowing near real time visualization, contributing to a better and quicker radiological intervention in numerous clinical situations (e.g. image guided biopsies on critically located organs) [1]. However, it requires the interventional radiologist (IR) to be positioned near the patient while the CT beam is on. Moreover, the hands of the IR must be positioned close to the beam, or in such positions that direct hand irradiation is possible. This means that high extremity doses can easily arise from frequent repetition of the procedure [2, 3]. One shows how Medical Physicists (MP) can play an important role by using ethical principles from modern Bioethics and Radiation Protection establishing a borderline between what is acceptable by means of risk and benefit for the IR, the patient and the society. Having the knowledge to evaluate the radiation risk from particular equipments associated to a given procedure, the MP are at a pivotal place to evaluate, from an ethical perspective, the whole circumstances and to give advice on the critical aspects of this practice and to reach a consensual solution. One also aims to highlight the need of Bioethics as part of the core curriculum of MP training, predominantly in face of new developing technologies that imply an increased irradiation risk.

[1] The British Journal of Radiology, 74 (2001) 1088-1090

[2] Health Physics 85 (2003) 165-173

[3] Alves et al., 8th International Workshop on Individual Monitoring of Ionizing Radiation, Oarai (Japan, Dec. 2012)

Paper Number: 0031

DENTAL RADIOLOGICAL PROTECTION - PROBLEMS, ISSUES AND CONTROVERSIES

Graham Hart[1], Margaret Dugdale[2]

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Although effective doses from most dental radiological investigations are generally low, they remain the most common medical radiological procedure.

The UK Health & Safety Executive's 'Radiation Protection News' (June 2010) said: "HSE's Radiation Team is concerned about the poor standards of compliance with IRR99 they have found during inspections at Dental Practices".

Data has been collected from direct measurements on >900 intra-oral and 120 panoramic sets for critical examination and routine testing, and from the provision of RPA / MPE Services to >180 general dental practitioners.

Intra-oral data shows still widespread use of circular collimators (75% of those tested); the clear advantage of digital imaging (mean dose 59% of film-based sets), the unrealised potential for dose saving in all types of set (maximum patient doses 0.13 - 6.53mGy); and marked differences in dose between manufacturers and model types of the same manufacturer.

Many key issues have arisen with regard to radiation protection:

- positioning of control box & isolator switch;

- need (or lack of need) for patient thyroid protection;

- need (or lack of need) for additional shielding to the walls and doors of dental surgeries;

- large variation in the numbers of examinations performed per set;

- large variation in both the level of training and information provided in dental radiation protection training courses; and

- issues with CBCT installation and testing.

Despite Regulation having been in place for many years, there remains a low level of compliance and significant potential for patient (and hence staff) dose reduction.

Invited Speaker

DERIVING AN UNCERTAINTY BUDGET FOR THE CROSS-CALIBRATION OF DOSEMETERS

Mark Worrall, David Sutton

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INTRODUCTION

A Medical Physics department responsible for the testing of a significant amount of x-ray equipment needs to have a number of dosemeters with which this testing can be undertaken. This allows for simultaneous equipment testing surveys as well as ensuring continuity of service when dosemeters are absent through having been sent for repair or calibration.

With so many dosemeters however come significant calibration costs if the intention is to send them all to a Secondary Standard Dosimetry Laboratory (SSDL). Such costs may well provide strain on department budgets.

It may well prove beneficial for departments to send only one single set of dosemeters (i.e. comprising radiographic, fluoroscopic, mammographic and CT detectors) away for calibration and then perform an internal cross-calibration for all others on the return of the calibrated field instruments. The aim of this work is to derive an uncertainty budget for the cross-calibration of dosemeters for use by such departments.

METHOD

All work will be undertaken with reference to the IAEA technical report 457 – 'Dosimetry in Diagnostic Radiology: An International Code of Practice'. All recommendations therein will be weighed against the likely capabilities of a medical physics department and methodologies changed where the report's advice is deemed impractical.

RESULTS AND CONCLUSIONS

We have determined that the uncertainty associated with the secondary calibration, dwarves all other uncertainties, such as kQ. The uncertainty budget will be presented on the day.

Paper Number: **0013**

PATIENT SKIN ENTRANCE DOSES MEASURED DURING VARIOUS RADIOLOGICAL PROCEDURES BY CASO4: DY TL DOSIMETRY

Arun Chougule

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The use of ionising radiation as an important tool for diagnostic procedure is very well established and today more than one third of all crucial medical decisions are dependent on X –ray diagnosis, more so the early diagnosis of some diseases depends completely on x-ray examination.

In recent years there has been wide spread concern regarding radiation exposure to patients undergoing radiological procedures. Even though the patient is benefited by then clinical procedures, knowledge of radiation dose received by the patient during that particular radiological examination is necessary.

In India the DAP meter is not mandatory and therefore to know the patient radiation dose measurement is necessary. We at our institute have measured the patient skin entrance doses who undergoing various radiological procedures by using CaSO4: Dy TL dosimetry.

Present study deals with measurement of skin entrance doses in 500 patient undergoing KUB examinations, 150 patients undergoing radiography for cervical spine, 300 patients undergoing skull radiography. It is observed that the patient skin doses during KUB examination is 2.6- 6.0 mGy whereas the doses during skull radiography is 2.9 – 6.4 mGy.

It was found that CaSO4: by TL dosimetry is a versatile tool for assignment of patient doses and the doors were with the DRL.

The detailed results are presented in this communication.

Paper Number: 0021

PRE-IRRADIATION ANNEALING AND FADING CHARACTERISTICS FOR CLEAR POLYMETHYMETHACRYLATE PERSONNEL DOSIMETER

Mohammed Al-Bedri

University of Jordan, Amman, Jordan

The pre-irradiation annealing technique (Pre-IAT) at annealing temperature of 60°C and storage time of 48 h (60°C /48 h) of clear Polymethymethacrylate (PMMA) personnel dosimeter have been studied. Pre-irradiation and post-irradiation fading characteristics of PMMA were measured at storage times up to 90 days and at six different temperatures (0, 10, 25, 40, 50 and 60oC). PMMA personnel dosimeters stability after irradiated with 0.5 Gy test absorbed dose of β-particles have been investigated. The response of personnel dosimeters during pre- and post-irradiation storage at 60oC/48 h shows good stability for at least 90 days. PMMA samples were irradiated with β-particles from 90Sr beta source showed a decrease in the mean molecular weight with increasing absorbed dose range from 20 mGy - 1.44 Gy, which is attributed to chain scission of PMMA.

Paper Number: **0286**

HUMIDITY INFLUENCE ON THERMOLUMINESCENT DETECTORS DOSE RESPONSE

Aleksandra Jung, Wiktor Komenda

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Thermoluminescent detectors (TLDs) are mostly used for personal and environmental dosimetry and also in studies of dose distribution in phantoms. Even though plenty reports based on TLDs application are available, the investigations of humidity influence on TLDs dose response are limited. Detectors should be protected against humidity, however quantitative water influence on readout has not been well clarified so far. Particularly, it may have a significant impact in the accuracy of water phantom dosimetry as well as environmental outdoor measurements. The purpose of this study was to evaluate TLDs response for the same dose but in different wetness conditions.

All TLDs (LiF:Mg,Ti and LiF:Mg,Cu,P manufactured at the Institute of Nuclear Physics in Krakow as MCP-N and MTS-N) had form of circular pellets Φ 4.5 × 0.9 mm. Detectors were annealed and calibrated using standard procedures. Dry detectors were irradiated at a dose of 1.6 mGy and read out, then immersed in water for 5 minutes, irradiated at a dose of 1.6 mGy and read out once again. Analogous procedure was repeated for 1 hour and 24 hour immersions in water. Readouts were performed using a RA-04 reader.

Measurements provided so far, shown that MCP are more humidity sensitive than MTS (relative dose changes compared to baseline at 24 hour, 5% and 21%, respectively). MCP showed significant difference when compared with control results already after 1 hour water exposition (18% higher dose), what is of major importance for absolute dose validation. Further investigations are being carried out.

ICMP 2013

DAY 2, TRACK 2

GLOBAL PATIENT EXPOSURE OPTIMISATION

Invited Speaker

RELEVANT IONISING RADIATION LEGISLATION IS AN ESSENTIAL ELEMENT IN THE PROTECTION OF PATIENTS

Steve Ebdon-Jackson

CRCE, Public Health England

Radiation protection legislation and regulations provide the framework within which employers can develop a radiation safety culture and professional practitioners can safely provide medical exposures to patients and others.

Policy makers and regulators must appreciate however, that on a day to day basis the successful impact or otherwise of regulations depends on professional practitioners appreciating and supporting their use. This can only be achieved if regulations enable, rather than obstruct, good and safe practice and are perceived as relevant by doctors, scientists, radiographers and others.

While regulations must conform to the established legal processes and structures in place within a Member State, they should be developed through consultation with employers and professional bodies to ensure future compliance. Ideally they should be flexible enough to stand the test of time and provide scope for guidance to support changing practice and evolving thinking.

The formulation of current UK regulations will be considered to demonstrate these points and examples for the future will be provided from the negotiation of the latest Euatom Basic Safety Standard Directive.

Invited Speaker

EXPERIENCES IN THE IMPLEMENTATION OF OPTIMIZATION OF PATIENT PROTECTION WHEN RESOURCES ARE LIMITED

John Le Heron

IAEA, Vienna, Austria

The International Basic Safety Standards set the requirements for radiation protection in all areas of radiation use, including medical uses of radiation. For radiation protection for the patient this is achieved through the radiation protection principles of justification and optimization. Optimization of protection and safety is comprised of several components, as set out in the BSS – namely, design considerations, operational considerations, calibration, dosimetry of patients, diagnostic reference levels (for imaging procedures), and quality assurance. Many of these are "background activities" aimed at ensuring equipment performs in an accurate, reproducible and predictable manner, resulting in the delivery of the amount of radiation expected. The ultimate manifestation for the individual patient undergoing a radiological procedure in diagnostic imaging is the procedure protocol for the room in which the procedure is about to take place – the selection of technique parameters that determine the dose received by that patient and the resulting image quality. All of these activities and processes depend on resources – qualified personnel and specialist equipment and instruments. How effective is the implementation optimization of protection and safety in countries where such resources are lacking or are limited? This presentation will discuss experiences of some countries in the African region, looking at what is being performed, by whom, the challenges being faced, and how progress towards the implementation of optimization might be achieved.

Paper Number: 0256

NATIONAL MODELS FOR PATIENT DOSE ASSESSMENT PROGRAMMES AND OPTIMISATION OF PROTECTION

Colin Martin

Greater Glasgow and Clyde Health Board, Scotland, UK

A survey was undertaken to determine approaches to optimisation of patient protection in diagnostic radiology across the world. A questionnaire was sent to medical physics contacts and 137 completed survey forms returned from 48 countries. Responses form a biased sample since they represent primarily medical physicists actively involved in diagnostic radiology. Nevertheless results provide a picture of variations in approach and practice across the globe. Organisational arrangements for service provision follow five basic models. 1) Hospital medical physicists take the lead in Western Europe and Australia with radiographer involvement. 2) Private medical physicists test equipment and have responsibilities for optimisation in Brazil, the USA and New Zealand. 3) Government personnel and service engineers test X-ray equipment for many countries in Africa and Asia. 4) University personnel have significant involvement in Eastern Europe. 5) Radiographers play the predominant role in Thailand and other countries where numbers of medical physicists are limited. Testing of equipment prior to clinical use was generally high for most regions, but the frequency was lower in the American continent. There was considerable variation in the regularity of subsequent testing. The prevalence of patient dose surveys was high in Europe, but lower in other continents. In order for management of patient dose to be effective, results from equipment testing and patient dose surveys must feed into programmes for optimisation of protection. This requires collaboration between professionals involved, so that action is taken upon findings, but this did not appear always to be the case.

Paper Number: 0054

IAEA SURVEY OF PEDIATRIC COMPUTED TOMOGRAPHY PRACTICE IN PAKISTAN PROCEDURES AND PROTOCOLS

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[1] Institute Of Nuclear Medicine And Oncolgy Lahore, Lahore, Pakistan, [2] Institute Of Child Health, Lahore, Pakistan

ABSTRACT

OBJECTIVE
To survey procedures and protocols in pediatric computed tomography (CT) in Pakistan.

METHODS
Under a project of the International Atomic Energy Agency, 45 CT facilities throughout the country responded to a survey of CT technology, exposure parameters, CT protocols and doses.

RESULTS
Modern MDCT systems are available in 70 % of the facilities surveyed, dedicated pediatric CT protocols available in 90% . However Specific CT protocols for certain age groups were unavailable in around 50 % of the facilities. Indication-based protocols were used in 40 % of facilities. Estimates of radiation dose using CTDI or DLP from standard CT protocols demonstrated wide variation up to a factor of 100. CTDIvol values for the head and chest were between two and five times those for an adult at some sites. Sedation was frequently reported and use of shielding and immobilization was not in routine use. Records of exposure factors were kept at 10 % of sites.

CONCLUSION
This survey demonstrates significant potential for improvement in CT practice and protocol use for children in less resourced sites .Dose estimates for young children varied widely. it provides critical baseline data for ongoing quality improvement efforts by the IAEA.and PNRA Pakistan regulatory authority for reduction in pediatric doses.

KEYWORDS
Paediatric CT . Patient doses . Radiation protection, CT protocols.

Paper Number: 0132

VARIATION IN THE CT PEDIATRIC HEAD EXAM RADIATION DOSE IN USA: PRELIMINARY RESULTS FROM AN ONGOING SURVEY OF US HOSPITALS

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PURPOSE

To study variation in radiation dose for CT pediatric head exams using a national survey

MATERIALS AND METHODS

A survey was distributed to a stratified random sample of U.S. community hospitals (N=751). Survey respondents provided information about CT scanner type, the scan protocol for pediatric head trauma (age 0-1 year) exam, and current dose levels (CTDIvol and DLP). The survey is currently underway; preliminary results are based on responses as of April 23, 2013. Dose data was stratified in two ways: 1) trauma vs. non-trauma hospitals; and 2) dedicated children vs. general population hospitals. Statistical significance was determined using Bonferroni-adjusted p-values for pairwise Wald tests comparing means across trauma center categories and p-values for pairwise Wald test comparing means across dedicated children hospital category.

RESULTS

Of hospitals that were contacted, 24 were ineligible (e.g. no CT, hospital closed, no pediatric patients), 4 refused, and 213 responded (29.3% response rate). Across all hospitals, the mean CTDIvol and mean DLP for a pediatric head CT exam for age 0-1 year were 24.1 mGy (95% CI: 21.8-26.5) and 335.9 mGy*cm (95% CI: 304.6-367.1), respectively. There was a significant difference in CTDIvol when comparing community trauma hospitals (higher dose) and non-trauma hospitals (p=0.05) and comparing dedicated children's and general population hospitals (higher dose) (p=0.01). No such significant difference existed when comparing the DLP.

CONCLUSION

Results from this study will bring dose awareness, provide guidance for establishing dose thresholds, and incentive to reduce dose when scanning pediatric patients.

Paper Number: 0315

ESTABLISHING A NATIONAL DOSE INDEX FOR PEDIATRIC CARDIOLOGY AND CT PROCEDURES: WHAT CAN WE DERIVE FROM IT?

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The King Faisal Specialist Hospital & Research Centre in Riyadh Saudi Arabia is the largest medical center with the most number of pediatric patients for these procedures. The study aims to provide a national dose index on pediatric doses for PDA and COA cardiology procedures and CT chest and abdomen. A total of 800 and 1,040 pediatric for cardiology and CT respectively were included in the study. Patient demography (weight, age, gender and height or body mass index), were obtained from the patient files. The exposure parameters for cardiology and CT, including the dose area product and CT dose length product values were also recorded for each patient. Patients were grouped into age groups 0 for neonates, 1, 5 and 10 years old. Effective dose were estimated for each patient. Initial study showed that PDA procedures could give the highest average effective dose for all ages. An effective dose conversion coefficient of 120cGy-cm2 was obtained when all ages are pooled. CT effective doses can vary from 15 to 44 %. Data shows that normalized dose conversion coeffcients for CT chest can vary from about 10 to 25% for the different effective cylindrical diameters. From the dose indices, a dose conversion coefficient of per age group can be derived. A dose calculator can be developed that will estimate the effective dose when any of the weight, height or BMI data is available and will readily provide information of the patient dose for optimization of protection.

Paper Number: 0343

DOSE AUDIT THE EASY WAY? AUTOMATIC RECORDING OF EXPOSURE DATA USING DICOM MPPS

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PURPOSE

Many hospitals audit patient dose by recording exposure or dose information manually (either in a radiology information system or on paper). Much of this information can be captured automatically from modern digital radiology equipment, for example using DICOM MPPS. Unfortunately many of the radiology information systems that are currently available are unable to make direct use of information in this form. The aim of this project was to devise a stand alone method to automatically collect patient dose data without the need for manual intervention, thus reducing transcription and dose unit errors.

METHODS AND MATERIALS

Dose information from a year of DR studies on three GE Definium plain radiography systems and CT studies on Philips Brilliance equipment has been captured using MPPS, a subset of this data was validated against information from the radiology information system which had been manually transcribed from the X-ray / CT consoles, as well as ion chamber measurements using exposure data.

RESULTS

Several issues were identified, including identification of the projections for DR studies with more than one view per examination. These issues will be discussed, and solutions presented.

Conclusion: Automated capture of dose data from some DICOM MPPS capable radiology equipment is practical even when the radiology information system in use does not support it, and has advantages over manual recording of dose information.

ICMP 2013

DAY 2, TRACK 2

EFFECTIVE DOSE, RISK AND ALL THAT

Invited Speaker

ICRP ADVICE ON THE USE OF EFFECTIVE DOSE

Dr John Harrison

Centre for Radiation, Chemical and Environmental Hazards, Public Health England, UK

The International Commission on Radiological Protection (ICRP) introduced and defined effective dose as a radiation protection quantity for use in the control of exposures. It provides a very convenient risk-related quantity that can be compared with dose limits, constraints and reference levels. All exposures can be expressed in this quantity, irrespective of whether dose is delivered externally or internally, the time-course of dose delivery, and whether exposures are uniform to all organs or confined to particular organs of regions within organs. However, the convenience of effective dose has led to its widespread use for purposes outside the intended scope of its application, including the estimation of risk to individuals from medical procedures. Useful guidance on restrictions on the use of the quantity was provided in the ICRP 2007 Recommendations. This guidance needs to be further expanded, and proposals made for the control of exposures and risk management as well as risk assessment in situations where 'effective dose' is not directly applicable. ICRP has set up a Task Group to consider the use of effective dose and methodology for risk assessment and provide guidance. The development of ICRP advice will be presented, focussing on medical applications.

Invited Speaker

THE APPROACH TO RISK ESTIMATION (AND ITS RELATIONSHIP WITH EFFECTIVE DOSE)

Richard WAKEFORD

The University of Manchester

In the absence of a comprehensive understanding of radiobiological mechanisms, estimates of the risks to health resulting from low-level exposure to ionising radiation are derived predominantly from epidemiological studies. In its 2007 Recommendations, the International Commission on Radiological Protection (ICRP) produced nominal risk estimates appropriate for radiological protection in the context of exposures at low doses or low dose-rates. The need for simplicity and practicality led ICRP to generate risk estimates that would form the technical basis of a framework of protection for application to workers and the public worldwide. For this purpose, ICRP used epidemiological data, primarily from the Japanese atomic-bomb survivors, to obtain lifetime radiation-induced excess cancer risk coefficients (risks per unit dose) suitable for global use with general and working populations. These nominal risk coefficients are not only sex- and age-averaged, but they must also incorporate different sensitivities of tissues to radiation-induced cancer, different background risks of cancers between populations, a dose and dose-rate effectiveness factor (DDREF), and the different health detriments posed by different cancer types. The (much smaller) nominal detriment-adjusted hereditary disease risk coefficients must also be included to give the overall nominal risk coefficients for stochastic health effects appropriate for everyday radiological protection across the world. To account for the radiobiological effectiveness of different radiations, a radiation weighting factor is applied to the tissue absorbed dose to give the tissue equivalent dose, and the distribution of equivalent doses between tissues of differing radiosensitivity is taken into account by applying tissue weighting factors, to give the effective dose. It must be appreciated that the effective dose, and the route to it from fundamental scientific data, are constructs designed to provide a radiological protection framework for practical application throughout the world, and these concepts should be used outside this context with great care.

Paper Number: 0260

EFFECTIVE DOSE IN MEDICINE: WHEN, WHERE AND HOW TO USE IT.

Colin Martin

Greater Glasgow Health Board, Scotland, UK

If the medical community are to take account of radiation health related detriment, they need an appreciation of radiation risk for the wide range of procedures performed. Effective dose describes radiation health detriment in terms of a single variable, with which clinicians and others not working in radiation protection can potentially become familiar. Its simplicity means that it is easier for clinicians to understand, remember and use when making judgements in everyday practice. A primary purpose for which effective dose is used in Europe is to balance against potential benefits as part of the justification process in planning patient exposures. Generic values derived for reference patients inform clinicians of relative health detriments associated with different types of procedure and can be used for classifying patient exposures into broad risk categories. But measured dose quantities should be used when comparing doses for similar procedures. Effective dose relates to the aggregated health detriment for an age and sex averaged population, and the underlying approximation in the method of calculation must not be forgotten. Moreover, risks for different age groups from a uniform whole body exposure decrease by a factor of about five between the ages of 20 and 80 years, while those from breast and lung cancer are higher for females. The presentation considers the application of effective dose and methods of calculation from practical dose measurements. It also considers when quantitative assessments of risk may be required and how they can be calculated.

Paper Number: 0068

COMPUTED TOMOGRAPHY CHEST-ABDOMEN-PELVIS EXAMINATIONS IN SCOTLAND

Siobhan McVey, Shellagh Neil, David Sutton

Ninewells Hospital, Dundee, UK

CT Chest-Abdomen-Pelvis (CT CAP) is the second most commonly performed CT examination after CT Head and gives the largest contribution to the UK collective dose of any CT examination. There is no up to date reference level for this exam, despite the introduction of MDCT and more recently iterative reconstruction techniques. We have co-ordinated a CT dose survey of CT CAP across Scotland, with the aim of establishing a National Diagnostic Reference Level (NDRL) that reflects modern practice. We have also reintroduced the concept of achievable dose.

Each of 32 participating centres was asked to provide the displayed DLP for 30 standard-sized adult patients undergoing a standard CAP examination over a 9 month period. The standard protocol used for CAP examination was provided to determine if practice varied between sites.

The mean was calculated for each data set. The resultant third quartile and 50th percentile value of the distribution of the mean dose observed for CT CAP examinations was calculated. We analysed and will describe protocol and scan sequence variations and their influence on dose.

A Scottish NDRL of 840mGy.cm is proposed compared to the current UK NDRL of 940mGy.cm. The achievable dose for CT CAP exams in Scotland is 780mGy.cm.

This study has lead to the development of the SCoT DrOP (Scottish Computed Tomography Dose Optimisation) Project, which aims to use to use the nationwide PACS infrastructure to carry out a nationwide dose analysis on a significantly higher number of patients with subsequent intervention.

Paper Number: 0055

ANALYSIS OF CT PATIENT DOSE DATA FOR THE PURPOSE OF OPTIMIZATION

Supawitoo Sookpeng[1], Colin Martin[1], David Gentle[1], Rosario Lopez-Gonzalez[2]

[1]Health Physics, Gartnavel Royal Hospital, Glasgow, UK, [2]Institute of Neuroscience and Psychology, University of Glasgow, Glasgow, UK

The aim of this study is to determine how dose and image quality vary with patient size for CT scanners operated under automatic tube current modulation (ATCM). Patient dose surveys have been carried out using data downloaded from Radiology Information System and these have revealed high doses for a small proportion of patients on some CT scanners. However, the reasons for this were not known. DLP and CTDIvol values from CT chest abdomen and pelvis were surveyed for 30 patients from each of 14 CT scanners from different manufacturers. The images were accessed through the PACS and patient cross sectional area, tube current values along the scan and image noise at the heart and liver were measured from the CT images using in-house software. Regression analysis was used to test relationships between the parameters. Tests of ATCM systems using custom made and ImPACT phantoms were carried out in parallel. The results varied with CT manufacturer. The DLP greatly increased with patient size for Toshiba and GE scanners, while noise remained relatively constant. Inappropriate minimum tube current setting resulted in higher dose and more variations of noise. In Siemens scanners, image noise and patient dose increased with patient size, but within narrower ranges. Results from Philips scanners depended on selected types of modulation; use of angular modulation led to higher dose and a wider range of DLP. The results are being used to optimize scanner performance throughout the West of Scotland.

Paper Number: 0214

DOSE-TRACKING: A POWERFUL TOOL TO ENCOURAGE OPTIMISATION OF DIAGNOSTIC X-RAY EXPOSURES

Hugh Wilkins

Royal Devon and Exeter Hospital, Exeter, Devon, UK

Auditing patient doses from X-ray imaging procedures is an important element of patient safety and clinical governance. Conducting such audits is typically undertaken by manual, labour-intensive data collection methods, often sampling relatively small numbers of patient procedures with potential for transcription error. Dose-tracking is a relatively new informatics tool which greatly simplifies the automated collection of accurate dose indicators, facilitating the generation and analysis of large data sets and improved understanding of radiation doses sustained by patients from X-ray procedures.

This ‘big data' is potentially powerful in informing and driving patient dose-reduction programmes. It simplifies the derivation and implementation of diagnostic reference levels. It can be used to raise awareness of patient doses by X-ray operators and others. If introduced in an appropriate manner it can be very effective in encouraging a culture of doses as low as reasonably achievable.

The ability to collect large quantities of this data automatically is a by-product of the transition to digital radiology. DICOM radiation dose structured reports and IHE radiation exposure monitoring standards are catalysts in the emergence of dose-tracking informatics tools. The data can be collected from PACS, RIS or directly from X-ray systems. It is important to ensure that patient data is appropriately anonymised and that dose-tracking systems comply with information governance data protection requirements.

Dose-tracking data can be used retrospectively to facilitate statistical analysis of population doses or review of individual patient doses. It can also be used prospectively to alert operators to potentially high doses which may be averted.

Paper Number: 0060

INVESTIGATION OF SPACE AND TIME DEPENDENT DISTRIBUTION OF VERY LOW-LEVEL SCATTERED X-RAY RADIATION IN DIAGNOSTIC AND INTERVENTIONAL RADIOLOGY

Ivica PRLIC[1], Marija Suric Mihic[1], Mladen Hajdinjak[2], Dinko Babic[1], Sasa Schmidt[3], Zdravko Cerovac[4]

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Over the past 30 years human exposure to x-rays in the range of low photon energies (less than 300 keV) has significantly increased and it is therefore of great importance to detect and determine the actual potential effects of low dose radiation on living matter. The aim of research was to enhance and improve measurement reliability of existing passive and commercially available electronic dosemeters in the region of low and very low doses and dose rates. A model of the spatial distribution of scattered radiation produced within a patient's body and propagated within the interventional radiology and cardiology rooms, based on real diagnostic and interventional x-ray procedures is presented. Isodose surfaces represent results obtained from experimental measurements performed using twenty new developed active electronic dosemeters of type ALARA OD 3 and its unique measuring characteristic. Final goal of understanding the distribution of scattered x-ray radiation is to enable a prompt and easy estimation of maximum exposure for both medical workers and patients and to provide an appropriate level of protection. An example is given to demonstrate how model of scattered radiation, isodose curves and geometry model of the worker could be used to estimate maximum personal dose equivalent. These measurements enable temporal distinction between dose receipt (i.e. dose rate) and creation of typical temporal patterns for each interventional procedure performed on a patient. The extention of the concept of dynamic dosimetry to the interventional radiology and cardiology, which is made possible owing to temporal distinction capability of AED, is proposed.

Paper Number: 0170

NIRS EXTERNAL DOSE ESTIMATION SYSTEM FOR FUKUSHIMA RESIDENTS AFTER THE FUKUSHIMA DAI-ICHI NPP ACCIDENT

Shigekazu Fukuda, Keiichi Akahane, Shunsuke Yonai, Nobuyuki Miyahara, Hiroshi Yasuda, Kazuki Iwaoka, Masaki Matsumoto, Akifumi Fukumura, Makoto Akashi

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The great east Japan earthquake and subsequent tsunamis caused Fukushima Dai-ichi Nuclear Power Plant (NPP) accident. National Institute of Radiological Sciences (NIRS) developed the external dose estimation system for Fukushima residents. The system is being used in the Fukushima health management survey. The doses can be obtained by superimposing the behavior data of the residents on the dose rate maps. For grasping the doses, 18 evacuation patterns of the residents were assumed by considering the actual evacuation information before using the survey data. The doses of the residents from the deliberate evacuation area were relatively higher than those from the area within 20 km radius. The estimated doses varied from around 1 to 6 mSv for the residents evacuated from the representative places in the deliberate evacuation area. The maximum dose in 18 evacuation patterns was estimated to be 19 mSv.

Paper Number: **0049**

BIOLOGICAL MANAGEMENT OF RADIATION RISK IN MANNED DEEP SPACE MISSIONS

SMJ Mortazavi

Shiraz University of Medical Sciences, Shiraz, Iran

Solar particle events (SPEs) are primarily composed of low to moderate energy protons while isotropic galactic cosmic radiation is dominated by protons with a wider energy range. To date, different methods for physical shielding of spacecrafts as well as increasing biological radioresistance using radioprotectors or even adaptive response-induced radioresistance after exposure to low level chronic space radiation have been proposed to solve the problem of intense radiation in the space environment. Limitations of physical shielding such as extremely high cost of transporting heavy structures into space and their incapability to provide adequate shielding against heavy ions at an appropriate thickness, prompt us to explore biological methods for increasing radioresistance during space missions. Mortazavi et al have previously reported that screening of the candidates of long-term space missions by conducting Ground-based in vitro adaptive response studies before any mission identifies the individuals who respond well to low levels of ionizing radiation and reveal high magnitudes of radioadaptive response. They have also found that laboratory animals pre-irradiated with radiofrequency radiation were less susceptible to subsequent lethal effects of high doses of ionizing radiation Furthermore, Mortazavi et al have recently showed that based on their findings in an animal model, radiofrequency-induced adaptive response can be used as a method for decreasing the risk of infection during deep space missions. These biological methods for management of radiation risk in manned deep space missions will be challenging issues in future space exploration.

ICMP 2013

DAY 2, TRACK 3

CLINICAL ENGINEERING VITAL FOR EFFECTIVE HEALTHCARE

Invited Speaker

EQUIPMENT PLANNING: VALUE IN A TIME OF AUSTERITY

Dr Keith Ison

Guy's and St Thomas' NHS Foundation Trust, London, UK

You work in a healthcare organisation. You want your own and every other department to provide the best possible patient care, using the most appropriate and up to date medical equipment. Yet there is never enough money to go round. How do you get the most from what funding is available and make the best possible case for what you think should be purchased?

This presentation will consider the principles, practice and ethics involved in getting the best value from equipment purchases and in arguing for resources in an environment where money is in short supply. It will include ideas of practical value, whether seeking to influence decision makers, assess the value of new or novel technologies you are not familiar with, or set up ways to allocate resources and procure equipment more effectively. Whether you work in an equipment-rich hospital or cash-strapped healthcare setting, it aims to make you think differently about how you approach the purchase, specification and replacement of all kinds of medical equipment.

Invited Speaker

CLINICAL ENGINEERING LEADING HEALTHCARE TECHNOLOGY MANAGEMENT

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INTRODUCTION

Clinical Engineering has been defined as 'the application to healthcare technology of engineering skills and management in order to support and advance patient care.' Their formal education and training both in engineering and clinical knowledge enables Clinical Engineers to understand both the clinical application and the technology involved.

Healthcare Technology Management (HTM) has been defined as managing the selection, maintenance, integration and safe and effective use of medical equipment and systems (1). Equipment can range from a simple medical gas flowmeter to a complex MRI scanner system. All significantly impact on the safety and quality of care provided to patients. All need to be managed on a whole life basis.

MANAGING HEALTHCARE TECHNOLOGY EQUIPMENT

The authors have identified features of HTM, some unique to this field, which require a specific approach and which make Clinical Engineers uniquely qualified to lead the interdisciplinary thinking that must guide the risk management processes underpinning HTM strategy.

The effective use of resources to manage healthcare technology equipment (which is always seen as diverting money from direct patient care) requires engineering and clinical judgement. Although all users of medical equipment have a role in HTM, only Clinical Engineers have this as one of their core functions. They therefore have a responsibility to lead, innovate and develop efficient and effective HTM systems.

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Paper Number: 0038

IBEEP, MONITORING OF GRAVITY INFUSION

Maurice Janssen[1], Ger Windhausen[1], Albert van der Pijl[2], Robin Wijnobel[1]

[1]Orbis Medical Centre, Sittard-Geleen, The Netherlands, [2]Dexter Medical, Delft, The Netherlands

At the Orbis Medical Centre (OMC) at various departments fluid, medication or blood products are administered intravenous. The infusion fluid can be administered with a pump or with the aid of gravity. Dexter Medical introduces the iBEEP, a prototype of an infusion monitor, with the infusion bag hooked to the infusion monitor which displays the current infusion speed. In addition, the iBEEP has a tool to set the correct infusion speed as well as alarm functionality to indicate deviations from the set infusion speed. In a clinical trial the possibilities of the iBEEP set to work in the clinical practice of the OMC are critically evaluated.

Using the iBEEP 1. the quality of gravity infusion of non-critical infusion fluids can be improved, 2. the safety of gravity infusion can be increased and 3. the number of volumetric infusion pumps can potentially be reduced.

Paper Number: 0116

NOVEL PHOTOPLETHYSMOGRAPHY ASSESSMENT OF ENDOTHELIAL FUNCTION IN SYSTEMIC SCLEROSIS

Costanzo Di Maria[1], Alan Murray[1], Stephen Hedley[1], Bridget Griffiths[2], Neil McKay[2], John Allen[1]

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INTRODUCTION

Systemic sclerosis (SSc) is a connective tissue disease characterised by hardening of the skin and internal tissues. The lack of a clinical standard for detecting its early signs, like endothelial (dys)function (EFn), makes difficult the appropriate management of possible life-threatening complications. Photoplethysmography (PPG) is a non-invasive optical technology which measures the peripheral pulse and peripheral blood volume changes in response to cardiovascular challenges [1].

AIM

To employ PPG technology to assess EFn in SSc patients [2].

METHODS

Nineteen patients with SSc were compared to 23 sex- and age-matched controls. PPG pulses were collected at the index finger during a standard 15-minute reactive hyperaemia (RH) challenge, including 5-minute occlusion of the arterial blood flow in the arm. PPG waveforms were digitised at a sample rate of 2 kHz and then analysed off-line by bespoke Matlab software. EFn was quantified using the RH response slope.

RESULTS

Patients were not significantly different from controls for BMI and blood pressure. EFn was significantly lower in SSc, median(IQR) 0.005(0.003-0.009) a.u./s, than the controls, 0.013(0.009-0.020) a.u./s, $p<0.0001$. ROC analysis gave an AUC of 0.89 and an overall accuracy of 81% (cut-off 0.009 a.u./s).

CONCLUSION

This pilot study has shown the diagnostic value of novel photoplethysmography assessment of EFn in SSc patients.

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Paper Number: **0040**

SECURING LAPAROSCOPIC IMAGE QUALITY IN A CYCLIC PROCESS

Maurice Janssen[1], Ity Hoving[2], Yoran Paulus[1]

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Quality assurance in Minimally Invasive Surgery has long been a 'hot item' in healthcare. Especially image quality during these interventions is vital and thus securing it is necessary.

The light and image guides (optics) are in a continuous process of use, transport, cleaning and sterilization, in which the Central Sterilization Department (CSD) plays a central role. A CSD however often does not have 1. sufficient knowledge for visual assessment of image quality and 2. a solution for the accurate and precise measurement (test, accept and reject) of optics with minimal "Human Factor".

At the Orbis Medical Centre (OMC) it turned out that measuring quality at a CSD is not necessary and that the quality of optics can be realized in a cyclic process of a learning organization. Some aspects of this quality assurance are training, instruction, communication, compatibility, color coding, usability, registration, standardization and an optical check test card.

ICMP 2013

DAY 2, TRACK 3

DEVELOPING MEDICAL DEVICES

Invited Speaker

DEVELOPING MEDICAL DEVICES TRENDS IN PHYSICS PROVIDING SOLUTIONS TO TRENDS IN HEALTHCARE

Rene Aarnink

Philips Research, Eindhoven, The Netherlands

Philips Healthcare has a solid base in diagnostic imaging systems including Xray, Computer Tomography, Magnetic Resonance and Ultrasound imaging. These imaging modalities are routinely used to assess a patient's condition and, from that, derive a treatment regime for the identified disease. A current trend is that these imaging systems are more and more used during a variety of minimally invasive interventions: the imaging data provides a roadmap of the individual patient; the imaging system helps the physician to guide their instruments; the feedback by imaging supports monitoring capabilities of therapy progress. Besides, evolving technologies around imaging systems offer new possibilities to combine imaging techniques with medical devices: miniaturization offers integration steps; computer power offers real time coordinate registration; nano-technology offers new diagnostic workflows.

Trends in Physics are thus helping us addressing Trends in Healthcare by integrating imaging systems technology into minimally invasive devices. Computer-Aided-X helps us communicating with the user allowing physicians to absorb the growing amount of data generated in these integrated solutions. Advanced processing and visualization turns the data into information that can be made actionable in the interventional lab.

In the presentation, the grand challenges in healthcare will be linked to the technology options from physics, and resulting solutions will be introduced through recent innovations made available to the market. In addition, current research directions will be discussed as future promise for smarter medical devices.

Paper Number: 0142

ROBOT-ASSISTED RADIOFREQUENCY ABLATION OF LIVER TUMOURS - AN EARLY EXPERIENCE

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OBJECTIVE
To determine technical feasibility and fluoroscopic dose of robotic-assisted radiofrequency ablation (RFA) of liver tumours.

MATERIAL AND METHODS
Eleven patients (17 lesions, ≤3.0 cm diameter) were treated with RFA using the ROBIO Ex (Perfint Healthcare, Oregon, USA) CT-guidance robotic system. All the RFA were performed under general anesthesia. Following baseline CT scans, the lesions were identified. The RFA needle entry point and trajectory were then determined. The angulation of the needle, depth of lesion as well as the accuracy of placements was automatically calculated. The CT fluoroscopic dose for every patient was recorded. The performance level of the procedures was scaled by the interventional radiologist on a five-point rating (5-1: Excellent-Poor).

RESULTS
All the lesions were targeted successfully with the assistance of robot. The deepest lesion was 13.7 cm and the shallowest was 4.7 cm from the skin surface. No repositioning of needle was required in any of the patients. However readjustments of needle angulation were necessary in 6 lesions. The mean CT fluoroscopic dose, DLP and CTDIvol for the entire procedure were 956.09 ± 400.33 mGy.cm and 258.00 ± 125.46 mGy, respectively. Compared to historical data from our standard RFA procedure (n = 30), the total DLP and CTDIvol dose were 1703.93 ± 1152.37 mGy.cm and 632.73 ± 503.06 mGy, respectively. The mean performance level was 4.6 ± 0.5.

CONCLUSION
Robotic-assisted RFA appears to be technically easier, requires fewer number of needle passes, fewer check scans and has lower fluoroscopic dose.

Paper Number: 0338

ARE PRESCRIBED INFUSIONS RUNNING TO TIME?

Paul Lee[1], Patrick Oladimeji[2], Carlos Monroy Aceves[2], Harold Thimbleby[2]

[1]ABMU health Board, Swansea, UK, [2]Swansea University, Swansea, UK

This quantitative study looked at error logs downloaded from 127 infusion pumps (Smiths: Graseby 500) used in the clinical setting over a period of four years. The devices were in use between January 2008 and March 2011. In total, 348 error log files were downloaded. 3,600 infusions totaling over 9,000 hours were analysed. The devices were used across 7 different departments and the study showed as much as 44% (n=1637) infusion were interrupted due to alarms resulting in the infusion pump failing to deliver medication as prescribed.

Fifty-six percent of infusions (N = 2061) were administered without interruptions or disruptions. There were nine cases in which the infusions were restarted over 20 times and four cases in which they were restarted over 40 times. Further analysis of the data showed that the top four events that disrupt an infusion were excess pressure (1973), user action (i.e., user stopping the infusion) (1345), no flow above pump (880) and air bubbles (441). Others included door open (114), occlusion (77) and dead battery (58).

The alarms were further classified and our analysis provides insight into the type of alarms that are prevalent in each clinical area and how devices are used in practice. This has important implications for staff training, pharmacy departments (who order and check prescriptions), clinical engineers; who need to be aware of device functionality and alarm frequency, and designers of infusion pumps.

Paper Number: 0139

A PILOT STUDY OF A NEW SPECTROPHOTOMETRY DEVICE TO MEASURE TISSUE OXYGEN SATURATION

Gemma Abel, Michael Drinnan, John Allen

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AIMS

Tissue oxygen saturation (SO2) is widely useful, particularly in assessing peripheral vascular disease. Harrison et al developed a portable, low-cost spectrophotometer to measure superficial SO2, potentially enabling wider implementation if demonstrated to be reliable and accurate. Here it was compared with a commercial device, the LEA O2C. The repeatability of each device and agreement between them was assessed.

METHODS

20 healthy volunteers were studied with both devices simultaneously. Measurements were made on the forearm and finger sites, and progressive reductions in oxygenation were induced using a pressure cuff inflated around the upper arm. The pressure was increased to 50, 100 and 200mmHg and measurements were taken every 30s. 16 volunteers returned for repeat measurements within 2 weeks of their initial study. Repeatability of both devices was quantified using coefficients of variation (CoV). Agreement between devices was assessed using the Bland Altman method.

RESULTS

The commercial device showed slightly better repeatability (forearm, finger CoV = 14.2, 17.4%) than the Harrison device (19.6, 19.2%). There was no significant bias between devices.

CONCLUSION

Currently, the Harrison device should not be treated as a replacement for LEA O2C. The differences might be attributed to the design of the Harrison probe, and a second probe is under construction.

Invited Speaker

IS VENTRICULAR ARTERIAL (VA) UNCOUPLING AN IMPORTANT INDICATOR TO OPTIMISE MANAGEMENT IN PULMONARY HYPERTENSION.

Paul White[1,2], Colm McCabe[3], Stephen Hoole[4], Richard Axell[1,2], Andrew Priest[1], Leonard Shapiro[4], Joanna Pepke-Zaba[3]

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Understanding the adaptive mechanism of right heart (RV) dysfunction is important in management of Pulmonary Hypertension (PH). Real time pressure volume (PV) loops can be used to calculate end systolic elastance (Ees) and pulmonary arterial elastance (Ea) to produce an index of ventriculo-arterial (VA) coupling (Ees/Ea), which best describes the functional ineraction of RV and pulmonary artery

Eighteen patients total were recruited, eight underwent cardiac MR (CMR) to compare conductance and CMR derived RV volumes (axial slices). 12 had chronic thromboembolic obstruction of the pulmonary artery, 6 of whom fulfilled diagnostic criteria for PH and 6 of whom did not. 6 further patients undergoing closure of patent foramen ovale for minor neurological deficit were studied as control subjects. A conductance catheter (Millar Instruments; Houston, TX) was inserted under fluoroscopic guidance across the tricuspid valve towards the RV apex. Catheters were placed along the longitudinal axis of the ventricle Single-beat estimation of maximal pressure during isovolumic contraction using a curve fitting algorithm was used to calculate Ees.

Correlation between CMR and conductance-derived RV volume was best for stroke volume ($r = 0.75$, $p = 0.03$) with only modest correlation seen for end diastolic volume and end systolic volume ($r = 0.50$, $p = 0.26$, $r = 0.63$, $p = 0.12$ respectively). Heart rates were comparable between both disease groups and controls. Systolic contractility defined by RVSWI, PRSW, dp/dt max and Ees was higher in the PH group compared to other groups with enhanced contractility associated with faster isovolumic relaxation (lower Tau). The 'No PH' group exhibited higher Tau signifying impaired diastolic relaxation relative to controls and those with elevated haemodynamics. Ea did not differ between 'No PH' patients and controls consistent with their similar haemodynamic profile.

Using single beat analysis, we have reaffrirmed previous findings of increased ventricular contractility in response to high afterload hence supporting a clear association between elevated haemodynamics and VA uncoupling in pulmonary hypertension. Furthermore, changes in RV pressure volume loop morphology signify adaptive remodelling in the RV in response to chronic thrombotic obstruction without elevation in haemodynamics. Load independent assessment of diastolic relaxation demonstrates adaptive prolongation of diastolic RV relaxation in patients with near normal haemodynamics that is overlooked by current methods of assessment. Together these data suggest diastolic dysfunction in the RV may be an early pathological response to increased afterload within the pulmonary circulation.

ICMP 2013

DAY 2, TRACK 3

HOW TO ENSURE SAFE USE OF MEDICAL DEVICES

Invited Speaker

HOW THE SCIENCE OF HUMAN FACTORS IMPROVES THE SAFE USE OF MEDICAL DEVICES.

Professor Peter Buckle

Division of Surgery, Dept of Surgery and Cancer, Faculty of Medicine, Imperial College London

Design is a structured process for identifying problems and developing, testing and evaluating user focused solutions. Application of the human factors design process to healthcare could generate products, services, processes and environments that are intuitive, simpler, safer to work within, easier to understand and more efficient to use. By contrast, design that does not follow such a structured approach is likely to be confusing, less effective and potentially dangerous to medical staff or patients. Achieving an appropriate level of understanding of complex systems is an essential first step if risk is to be reduced.

Much of the research over the past decade has helped develop an improved knowledge base that should be helpful in the design of systems for health. However, the complexity of the challenges, the difficulty of implementing and sustaining interventions and the current economic climate continue to stretch the ability of researchers to deliver better systems and provide evidence of improved practice. The publication of Design for Patient Safety (Cambridge, Surrey and RCA, 2003) marked a huge step forward, enabling systems ergonomics thinking to be incorporated into the development of safer healthcare / care systems.

Human factors specialists (also known as Ergonomists) and systems engineers have long since recognised that enhancing performance and reducing risk in complex socio-technical environments requires an emphasis on design (or re-design) at a systems level. In typical work systems this includes a consideration of people / users, equipment, jobs, tasks and the socio-technical context of the work. Models of how this can be achieved will be presented and examples to support the benefits of this approach will be provided.

Paper Number: 0159

COMPATIBILITY OF VENTRICULAR ASSIST DEVICES WITH MAGNETIC RESONANCE IMAGING

Matthew Gardner[1], Huw Griffiths[2], Richard Hugtenburg[3], Graham Foster[4]

[1]Medical Physics, University Hospitals Birmingham NHS Foundation Trust, Birmingham, UK, [2]Medical Physics & Clinical Engineering, Singleton Hospital, Swansea, UK, [3]College of Medicine, Swansea University, Swansea, UK, [4]Calon Cardio-Technology Ltd, Swansea, UK

Ventricular Assist Devices (VADs) aim to provide mechanical support to a failing heart. The use of Magnetic Resonance Imaging (MRI) and development of VAD technology may give rise to occasions in which VAD-implanted patients require MRI examination. The purpose of this project was to investigate the compatibility concerns associated with this using a pair of VADs. Force measurements were made with the VADs suspended in the static magnetic field of a 1.5T MRI scanner. The effect on image quality was investigated subjectively using a simple phantom with the smaller VAD attached. A theoretical model was developed to calculate the force and torque experienced by an arbitrary object in the static field of an MRI scanner, considering the objects physical properties and the spatial variation of the field. The VADs experienced forces of order several Newtons and caused severe image distortion when placed in the imaged region. The model overestimated the maximum forces experienced by the VADs by up to a factor of two but did accurately predict the maximum force experienced by a simple Iron sample. The results indicate that VAD patients should not undergo MRI examination. The model demonstrated promising accuracy for a simple sample, but was not successful for a more complex structure. It is believed that the assumption that the VAD rotor magnets are magnetically saturated caused the overestimation, so the model predicts a theoretical maximum of the force and torque. Further work will include refining the model and quantitatively assessing the VADs influence on image quality.

Paper Number: **0346**

THE IV DRIP RATE APP.

Paul Lee[1], Mark Davies[2]

[1]ABMU Local Health Board, Swansea, UK, [2]Swansea University, Swansea, UK

Our organisation carries out over 100,000 intravenous infusions each year (15 million+ in the UK) and our nursing staff had no standard, reliable way to calculate infusion rates for IV therapy. Some nurses relied on memory, hand-written lists, even wooden tongue depressors with crib-notes written on them. When student nurses asked how to calculate infusion rates, qualified staff very often had no formal way to teach, train or offer advice on the correct methods to calculate these rates.

Literacy and numeracy is high on the agenda of the Welsh Government and Dept. of Health. Nursing Journals and local press were quick to criticise a lack of numeracy skills and articles were published around this topic. Studies have shown the lack of numeracy skills in healthcare and recommend tools to assist nursing staff in their job role and this is how the project began.

A series of help tools, a software programme, pocket cards, training courses and most recently an iPhone App. were developed to assist and help nursing and medical staff reduce risks when calculating infusion rates for IV therapy. To date, the app. has sold over 10,000 copies world-wide and used in over 22 different countries. A move to make this available on other hand held devices is planned for 2013.

These simple-to-use products can help many organisations support staff in their every day working life and address what is considered to be an essential skill, not just for nurses, but for all its employees.

Paper Number: 0039

NORMOTHERMIA DURING OPERATING PROCEDURES

Maurice Janssen, Rens Engels, Karen Kroonen, Fabian Tijssen

Orbis Medical Centre, Sittard-Geleen, The Netherlands

For every operated patient it is important to prevent perioperative periods of hypothermia, to reduce the risks of postoperative infections. A normothermia policy aims at a patient's temperature between 35.5 and 37.5 °C at the recovery unit, measured using an ear thermometer. The implementation of a solid normothermia policy requires knowledge of the most important factors leading to cooling.

We investigated the patients' temperature during the whole OR cycle, i.e. from nursing ward back to the nursing ward, using an ear thermometer. The temperature was measured in 430 patients at the nursing ward, arrival holding, arrival OR, incision, wound closure, arrival recovery ward and arrival nursing ward.

14.9 % of the operated patients arrived with hypothermia at the recovery ward with an average temperature drop of 0.8 °C, which occurs between holding and recovery. Different patient heating interventions were evaluated on their effectiveness upon normothermia. Our recommendations are to

· preheat the OR table

· use the Ranger © blood and fluid warmer during every OR

· use active heating blankets such as the Barrier © EasyWarm or the Bair Hugger to prevent cooling of a patient

· set the OR room temperature at 20 °C and plenum temperature at 18.5 °C

Paper Number: 0046

EXPERIENCE WITH THE IN-HOUSE RADIOTHERAPY MACHINES GANTRY COUCH ANTI-COLLISION DEVICE

Senthilkumar Shanmugam[1], Karthik S[2], Vasanthamalai S[1]

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All radiotherapy machines have moving parts, needs some safety measures to maintain the accuracy and safety of the patients. The moving parts of radiotherapy machines may cause collision between the treatment head and the table. If a patient interferes, it results in severe injuries. In this study we have developed a low cost gantry couch anti-collision device(GCACD). The GCACD consist of an IR(infrared) emitter and receiver, computer based micro controller circuits, LCD display, LED light source, an Acrylic holding device, a magnetic support, and an alarming device. GCACD is fixed in the lower surface of the gantry head. The threshold distance can be varied when adjusting the threshold selector. When the fixed pre threshold limit is exceeded, the LED will glow; at the same time the alarming device produces sound. On hearing the sound the technologist can stop the movement of the machine. If the output device is connected with the Radiotherapy machine, the device can stop the movement automatically when the fixed pre threshold limit is exceeded. GCACD was used to monitor the movement during the radiotherapy using different types of phantoms and 75 patients. Our method correctly confirmed clearance between the patient/treatment table and the gantry. GCACD improves the performance of the machine and most importantly reduces the chance of collision. GCACD is effective in alerting the radiotherapy technologist during the gantry and couch movement. It provides safe working environment during the radiotherapy and prevents the machine as well as the patient from unwanted collision.

ICMP 2013

DAY 2, TRACK 3

CLINICAL COMPUTING IN THE HOSPITAL ENVIRONMENT

Invited Speaker

INTRODUCTION TO IEC 80001: MANAGING SAFETY AND SECURITY OF NETWORKS INCORPORATING MEDICAL DEVICES

Sherman Eagles

Co-convenor IEC/ISO Joint Working Group for IEC 80001

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An increasing number of medical devices are designed to exchange information electronically with other equipment in the user environment, including other medical devices. Such information is frequently exchanged through a network that also transfers data of a more general nature.

At the same time, networks are becoming increasingly vital to the clinical environment and are being required to carry increasingly diverse traffic, ranging from life-critical patient data requiring immediate delivery and response, to general corporate operations data and email.

Potential problems with this situation include:

– lack of consideration for risk from network problems during evaluation of clinical risk

– lack of support from manufacturers of MEDICAL DEVICES for the incorporation of their products into networks

– incorrect operation or degraded performance resulting from combining medical devices and other applications on the same network

– lack of security controls on many medical devices

– the conflict between the need for strict change control of medical devices and the need for rapid response to the threat of cyberattack

This presentation introduces the framework described in IEC 80001-1 and related guidance documents for addressing these potential problems. Addressing these problems requires cooperation between healthcare provider organizations, medical device manufacturers and IT vendors. IEC 80001 defines the roles, responsibilities and activities that are needed for this cooperation to manage the risk of medical devices on networks to achieve safety, security and effectiveness.

Invited Speaker

EXPERIENCE GAINED IN APPLYING IEC 80001-1 PRINCIPLES TO A MEDICAL IT NETWORK SUPPORTING A CLINICAL INFORMATION SYSTEM.

F.J. Hegarty[1], Silvana Togneri MacMahon[2], P. Byrne[1]

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[2] *Regulated Software Research Group, Department of Computing & Mathematics,Dundalk Institute of Technology & Lero, Dundalk Co. Louth, Ireland*

INTRODUCTION

IEC 80001-1:2010 [1] recognises that medical devices are incorporated into IT-networks to achieve desirable benefits1. The standard defines the roles, responsibilities and activities that are necessary for the risk management of IT-networks incorporating medical devices to address safety, effectiveness and data and system security. It applies throughout the life cycle of IT-networks incorporating medical devices and applies to responsible organizations, medical device manufacturers and providers of other information technology. IEC 80001-1:2010 draws on processes set out in ISO 14971:2007 [2] intended to be used by equipment manufacturers to identify hazards associated with medical devices. It also draws on ISO/IEC 20000-1:2011 [3] which specifies the requirements for an IT service provider to meet when implementing an IT service management system.

DISCUSSION

A Process Assessment Model (PAM) based on IEC 80001 has been developed by the Regulated Software Research Centre (RSRC). We used this PAM to review the existing processes used to support the ICU Clinical Information System in the hospital environment which incorporates a complex Medical IT Network and medical devices from a number of vendors. In doing so, we identified where these processes could be improved. We will discuss the difficulties encountered in applying the PAM, to a Hospital setting. We will give examples of where the intent set out in IEC 80001-1 was met within the hospital using processes usually predicated on multidisciplinary management of clinical processes and healthcare technology management. We propose that Clinical Engineers in hospitals can play a significant role in interpreting 80001-1:2010 for the hospital environment and in doing so ensure that Clinical Information Systems are managed appropriately.

1. IEC, IEC 80001-1 - Application of Risk Management for IT-Networks incorporating Medical Devices - Part 1: Roles, responsibilities and activities. 2010, International Electrotechnical Commission: Geneva, Switzerland.

2. ISO, ISO 14971:2007 - Medical Devices - Application of Risk to Medical Devices. 2007, International Organisation for Standardization: Geneva, Switzerland.

3. ISO/IEC, ISO/IEC 20000-1:2011 - Information technology —Service management Part 1: Service management system requirements. 2011: Geneva, Switzerland.

ICMP 2013

DAY 2, TRACK 3

TECHNOLOGY-ENHANCED EDUCATION IN MEDICAL PHYSICS

Invited Speaker

ONLINE EDUCATION AND TRAINING RESOURCES ON MEDICAL PHYSICS AND RADIATION PROTECTION

Madan M. Rehani, PhD

European Society of Radiology and International Atomic Energy Agency (IAEA), Vienna, Austria

Online resources for education and training on medical physics and radiation protection are available from a number of organizations such as International Atomic Energy Agency (IAEA), American Association of Physicists in Medicine (AAPM), Radiological Society of North America (RSNA), Health Physics Society (HPS) and in recent years from Image Gently and Image Wisely among others. Besides these web based resources, currently most publications that were earlier popular as hard copy are available electronically and online access is possible against payment. Essentially everything is available online, the difference being free or against payment. There is increasing tendency by journals to provide “open access” to users while they charge authors to sustain business. A recent publication of the International Commission on Radiological Protection (ICRP) No. 113 covers education and training aspects in radiation protection and provides list of web resources. A number of publications of ICRP and National Council of Radiation Protection and Measurements (NCRP) are considered of value by medical physicists. Two websites of IAEA, RPOP and human health campus provide extensive educational material. Of interest is the power point slides that are available for free download. International Organization for Medical Physics (IOMP) website provides list and link to educational resources.

Conclusion: Access to education and training resources on medical physics and radiation protection is much more easier today than in previous years. With search engines becoming more efficient, the availability of books and journal articles online, the online resources are not confined to lecture material, but cover all categories of knowledge resources.

Invited Speaker

E-LEARNING IN MEDICAL PHYSICS FOR CONTINUING PROFESSIONAL DEVELOPMENT

W.H. Round

School of Engineering, University of Waikato, Hamilton, New Zealand

When trying to access new knowledge to enhance our professional capabilities, many of us turn to the web in the first instance. There a lot of relevant material can be found, although some of it can be a challenge to find. Sometimes it is easily found, but it access to it may be restricted because of valid intellectual property ownership issues. In other cases, there seems to be no valid reason for restriction.

While some significant and highly successful resources such as EMITEL and Emerald are available, there is scope for a lot more material to be made available. A few web sites of IOMP's member organizations contain medical physics education resources or act as gateways to on-line materials, when they all should be major resource holders.

Also, as a profession we have yet to take full advantage of the opportunities afforded by teleconferencing for teaching either as part of resident training programs or for CPD. It can be cost and time effective, but it requires a high level of cooperation and organization.

This presentation will consider the different forms of e-learning and how clinical physicists can use them to best advantage. It will also consider that our profession needs to have a global strategy on how to make best use of the capabilities of e-learning and develop cooperative agreements to enhance access.

Invited Speaker

EMITEL E-ENCYCLOPAEDIA PRINT PROJECT – ASSESSMENT, UPDATE AND WAY FORWARD

S Tabakov[1], P Sprawls[2], F Milano[3], S-E Strand[4], C Lewis[5], M Stoeva[6], A. Cvetkov[6], V. Tabakova[1]

[1] King's College London, UK; [2] International Organization for Medical Physics; [3] University of Florence, Italy; [4] University of Lund, Sweden; [5] King's College Hospital, UK; 6 AM Studio Plovdiv, Bulgaria

The Medical Physics e-Encyclopaedia EMITEL (www.emitel2.eu) is now a widely used reference/educational tool, with 9000+ users per month. The development of this on-line tool was made by a large multinational team. The process continued from 2006 to 2010 and after its completion an additional project started to translate EMITEL on paper through CRC Press.

The paper describes the additional assessment of all articles by 7 teams working in parallel. The teams, including most of the original EMITEL contributors, were headed by the coordinators of the Encyclopaedia groups:

- Diagnostic Radiology: S.Tabakov, P.Sprawls, M.Lewis

- Magnetic Resonance: A.Simmons, S.Keevil, F.Stahlberg

- Nuclear Medicine: S-E.Strand, B-A.Jonson, M.Peterson

- Radiation Protection: C.Lewis, P.Smith, J.Thurston

- Radiotherapy: F.Milano, I-L.Lamm, C.Deehan, J.Chick

- Ultrasound: D.Goss, T.Janson

- General terms: G.Taylor, W.Hendee

The process was supervised by the Main Editors of EMITEL and coordinated by the Network Administrator V.Tabakova with the help of the CRC team headed by J.Navas and S.Thirunavukarasu. The update of the Web database was done by M.Stoeva and A.Cvetkov.

The assessment of the edited materials was at two stages – by the teams and by a group of MSc students from MSc MEP, King's College London. The e-Encyclopaedia text was additionally updated (both within the articles and with new articles). This resulted in inclusion of new graphic material and additional reference data. The final product was ready during 2012 and is released by CRC. The way forward is discussed from the point of view of the future update organization through IOMP.

ICMP 2013

DAY 2, TRACK 4

GENERAL NEW HORIZONS

Invited Speaker

RECENT ADVANCES IN NEUROLOGICAL PET STUDIES OF AWAKE, CONTINUOUSLY MOVING SUBJECTS: APPLICATIONS IN SMALL ANIMAL RESEARCH AND CLINICAL PRACTICE

Steven Meikle, Ph.D.

Professor of Medical Imaging Physics, Brain and Mind Research Institute, The University of Sydney, Australia

Positron emission tomography (PET) is used to non-invasively image and quantify biochemical processes in the brains of human subjects and animal models of human brain disorders. It provides important information about the neurochemical bases of brain function and debilitating disorders such as brain cancer, dementia, and drug addiction. In small animal PET, anaesthesia is used to prevent motion during the imaging procedure. Unfortunately, anaesthesia also interferes with key biological processes in the brain relevant to disease and precludes the study of brain function during learning tasks and complex behaviours. Similarly, in PET studies of children and uncooperative adults, sedation and occasionally anaesthesia, which are not without risk of complications, are used to minimise motion. In this presentation, recent developments to overcome these limitations will be presented. Instrumentation and computational methods will be described that enable the brains of awake, freely moving rodents to be imaged using high resolution PET while simultaneously studying their behaviour under controlled conditions. The potential translation of these advances to clinical PET studies of children and certain adult cohorts will be discussed.

Invited Speaker

MODERN COMPUTED TOMOGRAPHY AND SOME OF ITS APPLICATIONS

Xiaochuan Pan, Ph.D.

The University of Chicago

Computed tomography (CT) remains one of the most widely used tomographic imaging modalities, playing a dominant role in modern medicine and other disciplines such as security scans and material sciences. Since the mid of 1990's, CT has been experiencing a period of renaissance, as a result of the rapid advances in both CT hardware and algorithm developments. The superior spatial/contrast resolution, fast-imaging capability, and high degrees of imaging flexibility offered by modern CT technologies has opened upon ample opportunities for developing innovative applications and imaging protocols in medicine, biology, and material sciences. In this presentation, recent advances in CT technology and applications will be discussed, with an emphasis on the introduction of emerging system design of CT imaging for applications in biomedicine, security scan, and material sciences.

Invited Speaker

MODERN DIAGNOSTICS CALLS ON SMART AND ROBUST INTEGRATED SENSOR SYSTEMS IN ORDER TO TRANSFORM OUR HEALTHCARE.

Professor Jim McLaughlin

Nanotechnology and Integrated Bioengineering Centre, University of Ulster, Shore Road, Newtownabbey, Co. Antrim, Northern Ireland BT37OQB

Medical developments in the 20th century have contributed to an increase in life expectancy across the world-population. Consequently, technology must respond through continuous development in order to improve current and future healthcare regimes, as aging populations dictate the creation of healthcare responses to treat increasing numbers of patients with various chronic illnesses.

A number of innovative products have arrived on the market with the aim of modernising current healthcare systems to meet these demands. Some of these devices have been designed to facilitate the development of wearable wireless medical sensor applications, improved drug therapy and a range of rapid diagnostics devices that should impact on the ability to establish improved home-based monitoring via Connected Health with cost savings and improved patient care.

This talk will highlight global developments and work within my own laboratories at NIBEC, University of Ulster, which is providing the basis for intelligent healthcare systems as well as utilizing nanotechnology, integrated sensors, smart computing algorithms and large data analytics to provide new early warning robust systems that are already changing patients care-pathways and there is growing evidence of economic benefits.

ICMP 2013

DAY 2, TRACK 4

FROM MOLECULES TO LIFE

Invited Speaker

THE BIOLOGICAL RATIONALE OF HADRON THERAPY

Jan J. Wilkens

Department of Radiation Oncology, Technische Universität München, Klinikum rechts der Isar, Munich, Germany

Treating cancer patients with heavy particles like protons, neutrons and ions (often termed hadron therapy) becomes increasingly popular, with a rising number of clinical facilities that can offer this type of therapy. In addition to the general trend in radiation therapy of deriving “biologically adapted” treatment strategies, a careful consideration of “biological effects” is and was always a very important issue in hadron therapy. The reason for this is the fact that the biological effect (DNA damage, cell killing etc) of hadron beams not only depends on the dose (as one is used to in x-ray radiotherapy), but also very much on the local energy spectrum or “radiation quality” which varies dramatically inside a given patient. This is quantified by the “relative biological effectiveness” (RBE), which is the ratio of x-ray and hadron dose required to yield the same biological effect. If we are in a situation where the RBE in the target volume is higher than the RBE in the normal tissue, the therapeutic window widens and potentially offers a more effective therapy or less adverse effects. Treatment planning for hadron beams must try to make the best use of these biological effects, and needs to rely critically on our current ability to predict these effects by radiobiological modelling.

Invited Speaker

BIOLOGICALLY ADAPTED RADIOTHERAPY

Fridtjof Nuesslin

Technische Universität München

The primary goal of radiotherapy is to maximize the energy dose absorption in the tumor whilst minimizing the radiation exposure to the surrounding normal tissue. During the past decades various technologies emerged to precisely tailor the dose distribution to the shape of a given target volume. Examples are 3D-conformal methods, intensity modulated beams, image guided radiotherapy to compensate movement uncertainties, and particle beam therapy with protons and ions. However, advancement in imaging technologies challenges increasingly to expand optimisation of radiotherapy beyond the space and time domain by considering biological parameters such as radiation sensitivity, metabolic activity, oxygen status etc. Radioisotope imaging, molecular ultrasound imaging, MR-based molecular imaging and optical imaging provide information at the cellular and subcellular level of a tumor which can be used to modulate the dose distribution at the tumor correspondingly. In the clinical setting, biological information is more and more used by merging for instance PET- and CT-imaging in treatment planning. A new generation of hybrid MR-Linacs appear at the horizon which enable combined morphological and biological image guidance in radiotherapy. In particular, in preclinical settings biological factors influencing the radiosensitivity of a tumor can be investigated with a new class of instruments for high precision small animal image-guided irradiation. The concept of biological adapted radiotherapy is the response to the challenges of an individualized or personalized medicine in radiooncology.

ICMP 2013

DAY 2, TRACK 4

GRAY AWARD

ICMP 2013

DAY 2, TRACK 5

BIOENGINEERING

ICMP 2013

DAY 2, TRACK 5

EAMBES

ICMP 2013

DAY 2, TRACK 5

EDUCATION AND TRAINING IN RADIATION PROTECTION AND SAFETY FOR HEALTH PROFESSIONALS

Invited Speaker

EUROPEAN PROJECTS ON RADIATION PROTECTION EDUCATION AND TRAINING

Annemarie Schmitt-Hannig

Federal Office of Radiation Protection (BfS), Oberschleissheim, Germany

Within the European Commission's department "DG Energy", the draft Euratom Basic Safety Standards (Euratom BSS) were developed which specify, among other topics, requirements for radiation protection education, training and information in Title IV, requesting Member States to establish an adequate legislative and administrative framework for providing appropriate radiation protection education, training and information to all individuals whose tasks require specific competences in radiation protection. In particular, appropriate education, training and retraining has to be in place to allow the recognition of radiation protection experts, medical physics experts, occupational health services, and dosimetry services.

The European Commission has launched a number of projects in radiation protection with different objectives. A substantial part of their results will contribute to support the implementation of the Euratom BSS requirements on E&T in radiation protection by the EU Member States.

New and updated guidance documents with regard to E&T in radiation protection for Radiation Protection Experts (RPE), Radiation Protection Officers (RPO), Medical Physics Experts (MPE) and other medical professions are proposed or are already being developed, supported by European networks and authorities, such as EUTERP (European Training and Education in Radiation Protection Foundation), EMAN (European Medical ALARA Network) and HERCA (Heads of European Radiological protection Competent Authorities). In order to illustrate relationship and interaction of projects and networks on the European level, an overview of their objectives as well as a proposal for new guidance documents within the Radiation Protection Series of the Commission is given. The objective of this guidance is to assist EU Member States to establish an adequate framework for providing appropriate radiation protection training for those professionals whose work is closely related to radiation protection of workers, patients and public in all exposure situations on different levels and/or in various functions.

In a wider context, these projects and networks will form an integral part of the EU strategy, Europe 2020, which requires more effective investments in education, research and innovation. The SET-Plan (European Strategic Energy Technology Plan) "Education and Training Roadmap" puts forward key education and training activities to assist the development of the necessary cooperation frameworks among academia, research institutes and other partners. The strategy includes support for lifelong learning and borderless mobility, in particular, to ensure multilateral exchanges. Obstacles preventing the mobility of qualified experts should be removed (e.g. national regulations regarding specific job qualifications, cultural or linguistic barriers, or different technological cultures. The development of master courses is proposed which should be open to CPD programmes in line with the European Qualification Framework (EQF), bridging ECTS (European Credit Transfer and accumulation System) and ECVET (European Credit system for Vocational Education and Training).

Invited Speaker

TRAINING NEEDS AND OPPORTUNITIES IN RADIATION PROTECTION FOR PROFESSIONALS IN INTERVENTIONAL PROCEDURES

Madan M. Rehani, PhD

European Society of Radiology and International Atomic Energy Agency (IAEA), Vienna, Austria

Interventional procedures using fluoroscopy have been associated with radiation induced skin injuries and there is increasing need for radiation protection training of those involved in such procedures. Unfortunately interventionists in many countries excluding interventional radiologist (IR) lack training in radiation protection. It is all the more the case for clinical specialists like interventional cardiologists, electrophysiologists, vascular surgeons, urologists, orthopedic surgeons, anesthetists, gastroenterologists to name a few, who use x-ray machines outside radiology. The author has developed standardized training material which has been made available for free download as power point slides on RPOP website of IAEA. Interventionists from more than 55 countries have been trained through a dozen training events organized in number of countries. A network of Asian cardiologist in radiation protection and another network of gastroenterologists from Latin American countries in radiation protection has been established which are unique examples in the world. Information on patient and staff protection in these areas has been provided through RPOP website. An Annals of ICRP Publication 117 on “Radiological Protection in Fluoroscopically Guided Procedures Performed Outside the Imaging Department” has been made available. Medical physicists have thus huge resources available to them to equip themselves for meeting needs of training for doctors using fluoroscopy outside radiology. The most recent actions initiated by author is training of vascular surgeons.

Conclusion: Vast resources have been made available for medical physicists to meet increasing need of training of medical specialists using fluoroscopy outside radiology.

Invited Speaker

TRAINING IN CT DOSE OPTIMIZATION: SHOULD MEDICAL PHYSICISTS TAKE A MORE ACTIVE ROLE?

John Damilakis, PhD

University of Crete, Faculty of Medicine, Heraklion, Greece

There is strong evidence of increasing population dose owing to increasing frequency of CT examinations and to the high radiation burden for the patient. Surveys suggest that patient dose may vary greatly for the same examination even between sites with the same CT system. Optimization of radiation doses delivered in CT examinations, while maintaining diagnostic image quality is of great importance for the radiation safety of patients. An improved education and training of healthcare personnel performing CT on dose reduction strategies should be considered to keep the patient exposure as low as reasonably achievable.

EUTEMPE-RX project just launched by the European Commission will develop a dedicated education and training platform for the Medical Physics Expert in Diagnostic and Interventional Radiology. CT imaging and dose optimization is included in the modules selected for the first training course. ICRP states that 'Medical Physicists working in radiation protection (RP) and diagnostic radiology should have the highest level of training in RP as they have additional responsibilities as trainers in RP for most of the clinicians' (ICRP Publication 113, 2011). Medical Physicists should take a more active role in RP training of healthcare professionals involved in CT. Courses should be organized taking into consideration guidelines provided by the European Guidance document on radiation protection education and training of medical professionals developed by the MEDRAPET project (www.medrapet.eu) .This document provides detailed information for the RP education and training of medical professionals involved in different fields of applications of ionizing radiation.

Paper Number: **0029**

GROWING RADIOTHERAPY IN NIGERIA THROUGH SUSTAINED, TARGETED TRAINING - A SUCCESS STORY.

Ado Janse van Rensburg

Steve Biko Academic Hospital, Pretoria, Gauteng, South Africa

During my involvement in the commissioning of Radiotherapy Departments in Nigeria, I identified that the personnel in these departments, while all are dedicated professionals, were not equipped to run these departments. In my mind the best way to get these units to function would be to train a team from each hospital together and to follow it up with on-site application training.

A three month course, offered at our hospital, was designed consisting of a short academic refresher and practical hands-on training culminating in the drafting of Departmental policies and procedures. Ideally a team consisting of a Radiation Oncologist, two Radiotherapy Radiographers and one Physicist attended. General as well as profession specific training were offered.

Two week on site application training was given on completion of the course to help iron out unit specific problems. At the conclusion of the project a practical training sessions was given to representatives of all the centres in Benin City, Nigeria. A team consisting of a Planning Radiographer, Radiation Oncologist and me (Medical Physicist) helped to fine tune procedures.

A large number of lessons were learnt by all during this process. History will tell if this approach is the best solution to establishing radiotherapy in Africa. The initial signs are encouraging.

I would like to acknowledge the crucial role played in the success by:

LUTH, UNTH, UDUTH and UBTH Nigeria as well as Dr Taofeeq IGE

Steve Biko Academic Hospital, Dr A Hocepied and J Schoeman

Vamed Engineering Vienna, M Schoenthaler

Paper Number: **0398**

SOME IMPORTANT CONSIDERATIONS WHEN DESIGNING RADIATION PROTECTION EDUCATION AND TRAINING PROGRAMMES FOR HEALTHCARE STAFF

Hugh Wilkins

Royal Devon and Exeter Hospital, Exeter, Devon, UK

Medical exposure is by far the largest source of artificial radiation to which the world's population is exposed. In some countries average doses from medical exposures now exceed doses from natural radiation. ICRP and other authoritative bodies emphasize the need for more/improved radiation protection education and training (E&T) to protect patients and staff.

This includes undergraduate, postgraduate and CPD E&T for a wide range of staff. The challenges of providing this have increased as the use of ionising and non-ionising radiation has proliferated beyond traditional radiation departments. Many surgeons and physicians now operate medical X-ray equipment, generally without the detailed radiological knowledge of radiologists and oncologists, sometimes without support from radiographers. Many nurses and other healthcare professionals work in radiation environments, for example cardiac catheterisation labs, theatres and pathology labs. All these staff groups require appropriate E&T, whether for new employees or periodic updates for more experienced staff. In addition there is increasing recognition of the need for doctors, dentists and others referring patients for X-ray procedures to be better informed about radiation risks.

The task of providing such E&T often falls to medical physicists. Design and delivery of suitable courses is challenging, exacerbated by the wide range of staff groups requiring training at various stages of their careers. Given the scale of need, and different learning preferences, traditional lectures may well not be the most effective form of teaching. When designing courses it is important to consider not only content but also outcomes, assessment, feedback and, crucially, learners' needs.

Paper Number: 0025

THE TRAINING-RESEARCH X-RAY UNITS FOR MEDICAL PHYSICISTS EDUCATION

Aslamova Liudmyla[1], Melenevska Nadiia[1], Miroshnichenko Sergyi[2], Miroshnichenko Nataliia[1], Grabovska Elizaveta[1]

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[2]Production-Research Association "Teleoptic", Kyiv, Ukraine

According to IAEA International Basic Radiation and Safety Standards the people under the age of 16 years are not allowed to work with radiation sources (under Ukrainian standards - people under 18 years). It makes a sufficient problem for medical physics students in our university, which usually do not belong to professional exposure group. Our Training- research centre of radiation safety proposed the simulating of clinical students practice of the special training-research digital X-ray units, installed in X-ray protective box (lead skin-plating). The X-ray unit is remote-controlled, and does not need to be operated directly - the operator location can be in a safety and convenient place provided with computer. Such X-ray unit allows to perform different training problems for medical physics students: the measurements of transmission, absorption and scatter of X-rays by objects; the measurement of spatial resolution, dynamic range and quantum efficacy of detection in X-ray systems; the measurement of contrast and signal to noise ratio, and object detection; the problems of automatic objects detection and recognizing; the storage of axial projection, tomographic slices calculations and 3D pictures building. It also gives the possibility to train in creating working protocols, storage and transfer the obtained data via Intranet or Internet. The protected X-ray unit can be also used for research aims.

ICMP 2013

DAY 3, TRACK 1

PARTICLE RADIOTHERAPY

Invited Speaker

CHARGED PARTICLE RADIOTHERAPY

Hanne M Kooy, PhD

Department of Radiation Oncology, Massachusetts General Hospital & Harvard Medical School, Boston MA

Particle radiotherapy is characterized by paradoxes. It is the latest silver bullet yet has been part of external beam therapy for 50 years; it is too expensive yet more moneys have been expended on IGRT; it has demonstrably better dosimetry yet is not better clinically contrary to our main tenet. Nevertheless, particle radiotherapy, I argue, is the culmination of our technological aspirations. If we believe that technological means can achieve improved dosimetry and concomitant improved modulation of disease, then particle radiotherapy exceeds competing capabilities. Particle radiotherapy is, however, different. It must be considered independent of photon radiotherapy and not as its assumed continuation or evolution. If we further believe that radiotherapy can be advanced, then particle radiotherapy will optimally promote such advancement. I will argue that the inherent physical properties of particles, their interactions in patient, and supporting technologies for imaging and dosimetry deployed in an effective workflow embedded in a necessary software foundation will aggregate to the best-in-class solutions for future radiotherapy. In spite of its claimed superiority, however, particle radiotherapy must compete effectively in other functional aspects as well. These include effectiveness as a modality for most disease representation, accessibility for the broadest population, and especially efficiencies that affect cost. Finally, health care provision has reached its apogee and the societal question is not merely cost-benefit but absolute cost as well. As such, radiotherapy does have to bear its monetary responsibilities but not allow proton radiotherapy to be the easy target given its overall aim.

Invited Speaker

TREATMENT PLANNING FOR SPOT SCANNED PROTON THERAPY. THE NEXT STEPS

Tony Lomax

Centre for Proton Therapy, Paul Scherrer Institute, Villigen-PSI

There is a rapidly growing interest in proton therapy, particularly in spot scanned proton therapy. Although there are still only a handful of proton facilities actually using spot scanning clinically, it is widely recognized that the flexibility of scanning, and its natural extension, Intensity Modulated Proton Therapy (IMPT), means that it will become the dominant modality for delivering proton therapy in the near future. However, although extremely flexible and powerful, spot scanned proton therapy is also extremely sensitive to both anatomical changes of the patient and organ motions. In order to be able to best deal with both these issues, sophisticated treatment planning methods and strategies need to be developed. In this presentation, after introducing the basic concepts of proton therapy and treatment planning for spot scanning, we will look at three such treatment planning methods. First, we will introduce the concept of 'anatomically robust' planning, by which treatments that are robust to potential anatomical changes can be constructed. Second, we will make the case for highly efficient calculation systems and treatment planning workflows to move towards 'plan-of-the-day' strategies, combining both a-priori adaptions of the treatment based on daily imaging and a-postori dose reconstructions based on delivered log files. Third, we will look into methods for accurate four dimensional calculations and dose reconstructions for planning and optimizing the treatment of mobile tumours. In summary, there is still much work to be done in the treatment planning of spot scanned proton therapy. But only through such developments can the true potential of this exciting treatment modality be fully exploited.

Invited Speaker

DEVELOPING PROTON THERAPY IN THE UK

Dr Ranald MacKay

The Christie Hospital NHS Foundation Trust

Worldwide the number of proton therapy facilities treating patients is increasing exponentially. Currently increasing numbers of patients that require proton therapy in the UK have to travel abroad to receive treatment. This presentation will describe the programme to develop proton therapy at designated sites in England and will examine some of the key decisions regarding proton technology that will determine the quality of the delivered service. In particular it will examine how proton technology can deliver improved treatment to the required number of patients.

Paper Number: 0357

DEFINING THE CALIBRATION CURVE BETWEEN HOUNSFIELD UNITS AND MASS DENSITY IN THE XIO TPS FOR SPOT-SCANNED PROTON BEAM PLANNING, BENCHMARKED TO THE PSI STOICHIOMETRIC CALIBRATION METHOD: THE CLINICAL SIGNIFICANCE OF THE RELATIVE STOPPING POWER ENERGY DEPENDENCE.

Ruth Harding[1], Petra Trnkova[2], John Lilley[1], Vivian Cosgrove[1], Steve Weston[1], Tony Lomax[2], David Thwaites[3]

[1]Leeds Cancer Centre, Medical Physics and Engineering, Leeds, UK, [2]Paul Scherrer Institut, Centre for Proton Therapy, Villigen, Switzerland, [3]University of Sydney, Institute of Medical Physics, School of Physics, Sydney, Australia

In commissioning the XiO (Elekta-AB) proton treatment planning system (pTPS) for clinical use, an accurate mass-density(rho)to-Hounsfield-Unit (HU) calibration is required. For consistent comparison of the Xio pTPS to the in-house PSI-plan, the latter was used as a reference.

For spot scanning plans XiO uses an energy-dependant empirical relationship to derive mass-stopping-power-ratio (MSPR) from rho. This relationship was back-calculated to derive appropriate values for 'rho', giving consistent relative-stopping-power (relSP) values for each HU with the PSI clinical calibration for 200 MeV protons. The PSI calibration calculates relSP from the Bethe-Bloch equation using the stoichiometric method. MSPR was calculated from PSI relSP values and 'rho' found by numerical methods. The MSPR energy dependence is significant only at low energy and high density. Using 200 MeV as reference, ie. matched to the PSI calibration, the energy value was determined where the difference in relSP to that at 200 MeV reached 1% in cortical bone and the associated range error was obtained from proton-range tables.

For the non-linear part of the curve, the back-calculated 'rho' vs. MSPR agrees with forward calculation to 0.001%.The difference in relSP (to 200 MeV values) reaches 1% at 32 MeV; however the 32 MeV proton range is 11 mm, so range error is only 0.11 mm.

For 200 MeV protons, the Xio calibration gives consistent relSP with the PSI-plan calibration. At lower energies, XiO values are different, but the effect on range is small. Hence it is valid to use the single energy, 200 MeV, in the back-calculation.

Paper Number: 0248

AUTOMATIC BEAM PROFILER FOR PROTONS AND CARBON IONS PENCIL BEAMS AT CNAO FACILITY.

Luigi Raffaele[2], Pablo Cirrone[2], Giacomo Politi[2], Francesco Romano[2], Aurora Tamborini[3], Mario Ciocca[1], Claudio Viviani[1]

[1]CNAO (Centro Nazionale di Adroterapia Oncologica)), Pavia, Italy, [2]INFN Sezione di Catania e LNS (Laboratori Nazionali del Sud), Catania, Italy, [3]Università degli Studi di Pavia e INFN Sezione di Pavia, Pavia, Italy

At CNAO (National Center of Oncologial Adrontheraphy), in collaboration with LNS (National Laboratories of South), we started a project to develop a prototype detector for the caracterization of the CNAO beam line in the treatment room.

After good results obtained with the first prototype developed at LNS, we expect to achieve a good saptial resolution (<1 mm).

The detector will be used to:

1) Verify physical features of the pencil beam (profiles, FWHM);

2) Verify the accuracy of the pencil beam deflection in the XY plane under the magnetic field of the scanning magnets;

3) Verify the homogeneity of the radiation field.

The use of this system will allow to perform on-line beam monitoring, with a significant time saving compared to the currently used methods (EBT3 films). After the validation the system will replace films, with a considerable costs saving.

The detector consists of a scintillating screen (EJ212 - 25x25 cm2) coupled with a CCD camera.

Labview applications perform the acquisition and data processing.

Following the identification of appropriate materials, we assembled the components of the system mounting them into a case, to shield it from the external light.

The CCD camera is triggered with the spill emission of the beam and each time a trigger signal is received the CCD captures images at a selected frame rate, until an end trigger signal comes.

After preliminary tests of the software with a light source, we will perform measurements on protons and carbon ions beams.

A cross check with EBT3 films will be done to verify the performance and the reliability of the system.

Paper Number: 0179

A RETROSPECTIVE STUDY OF PROTON TREATMENT PLAN ROBUSTNESS IN THE SKULL BASE

Stacey McGowan[1], Francesca Albertini[2], Neil Burnet[1], Antony Lomax[2]

[1]University of Cambridge, Cambridge, UK, [2]Paul Scherrer Institute, Villigen, Switzerland

AIM
In proton therapy, consideration of plan robustness as well as dosimetric quality is required. This study retrospectively analyses the robustness of 16 IMPT treatment plans of the skull base to systematic range and random setup errors.

METHODS
The error-bar dose distribution (ebDD) proposed by Albertini et al was used to determine plan robustness. The ebDD can be achieved for the systematic range error arising from the uncertainty in Hounsfield Units or the random error arising from setup. The deviation from the initial planned dose in the brainstem, chiasm and CTV was recorded for both types of error modelled. For two cases, Error-bar DVHs (ebDVH) were used to anaylse robustness of four beam configurations and determine optimum starting conditions.

RESULTS
Range errors in all VOIs were less than the corresponding setup errors. OARs were most robust to range errors, whereas the CTV was most robust to setup errors. For the two re-planned cases the choice of beam orientation had a greater effect on robustness than number of beams, and the largest range errors were along the distal field edge. The PSI arrangement, ‘4star‘, proved preferential when balancing conformity and robustness, however, there exists a risk of overshoot in the brainstem. From the data a table was created to aid planners in terms of plan robustness aims in these VOIs.

CONCLUSIONS
The use of the ebDD and ebDVH proved effective in analysing plan robustness and the process of retrospective plan analysis could help establish site specific planning protocols in proton planning.

ICMP 2013

DAY 3, TRACK 1

STATE OF THE ART QA IN MAMMOGRAPHY

Invited Speaker

QUALITY CONTROL IN DIGITAL MAMMOGRAPHY: "KEEP IT SIMPLE"

Gisella Gennaro *

Leader of the EFOMP Mammo WG

MPE at Veneto Institute of Oncology (IRCCS), Radiology Unit, via Gattamelata 64, 35128 Padua, Italy

Alberto Torresin

EFOMP Scientific Committee Chairperson

MPE at Niguarda Ca' Granda Hospital, Medical Physics Dep., P.zza Ospedale Maggiore 3m, 20162 Milan, Italy

One of the aims of the European Federation of Organisations for Medical Physics (EFOMP) is to encourage exchanges between the National Member Organisations and disseminate professional and scientific information through publications and meetings. In particular, EFOMP, through a Workgroup within the Diagnostic Special Interest Groups (SIG), is working to publish a document on quality controls in digital mammography, with the main objective to develop a minimum set of easily implemented quality control tests that can be used to assure the performance of a mammography system within a set and acceptable range. It is intended that these be implemented as part of the daily routine of Medical Physics Experts and system users throughout Europe in a harmonised way so allowing results to be compared.

In this document quality control tests have been selected on the basis of their relevance/priority; in other words, to facilitate the process of harmonization, many tests included in other documents have been discarded because they were considered less important, while a smaller number of tests believed as relevant were included. The general approach followed by the EFOMP document is to be "tolerant" about technical image quality criteria, allowing use of different phantoms, according to possible differences in local regulatory, Country history, and resources. This makes the document "compatible" with other existing QA protocols, and applicable to a large scale.

Detailed description of test procedures and software tools developed for data collection and analysis will further help the achievement of the harmonization task.

ICMP 2013

DAY 3, TRACK 1

IMAGING AND ADAPTIVE RADIOTHERAPY TECHNIQUES

Invited Speaker

OVERVIEW OF ADVANCES IN IMAGING METHODS AND APPLICATIONS IN RADIATION ONCOLOGY

Phil Evans

University of Surrey, Guildford, UK

Imaging is an essential part of all aspects of model radiation oncology. Firstly it is important as input to the planning of the treatment to enable anatomically and biologically based delineation of the treatment target and adjacent radiation-sensitive normal tissue structures. This, in turn, allows optimal dose targeting using techniques such as intensity modulated radiotherapy and volume modulated arc therapy. Secondly imaging during treatment allows verification that the delivered dose distribution is as planned and gives the scope for treatment adaptation in response to tissue movement and changes. Thirdly imaging to follow up treatment allows quantitative monitoring of the treatment outcome.

Recent years have seen advances in all aspects of imaging with impact in radiation oncology. Functional imaging with CT, MR and nuclear medicine has seen the development of new methods and agents which give an indication of clinically important indicators such as perfusion, hypoxia and proliferation. How to use these methods in treatment planning is still a major research area, with clinical trials underway to relate their signatures to outcome.

Developments in imaging during therapy have seen much greater integration between the imaging system and treatment, with imaging now an intrinsic part of the treatment procedure in image guided radiotherapy. Examples include cone-beam CT integrated onto the treatment system, real-time 4D imaging systems to monitor moving anatomy and the development of image-guided procedures for brachytherapy, intra-operative radiotherapy and external beam treatment.

This talk will give an overview of some recent advances on imaging and their implications for radiation oncology.

Invited Speaker

IMAGING MOVING TARGETS IN RADIOTHERAPY

Steve Jiang

University of California San Diego, La Jolla, CA 92037, USA

4D cone beam CT (4DCBCT) is an important imaging modality for radiotherapy at lung or upper abdomen area due to its capability of providing respiratory phase-resolved volumetric images. Current standard reconstruction algorithm reconstructs images at different phases individually using a conventional algorithm. We have developed a new method that reconstructs 4DCBCT from motion vector-field domain. A motion vector-field for each phase is determined by solving an optimization problem, such that computed x-ray projections of the deformed reference CT match corresponding measured ones. We have evaluated our algorithm in both digital phantom and patient cases. Much improved image quality has been observed, such that the images avoid streak artifacts and attain correct HU values. The entire reconstruction algorithm is implemented on a graphics-processing unit for a high computational efficiency.

Paper Number: 0273

SEMI-AUTOMATED PLAN-OF-THE-DAY SELECTION BASED ON LIPIODOL MARKERS IN ADAPTIVE RADIOTHERAPY FOR BLADDER CANCER

Silvia Wognum[1], Luiza Bondar[2], Jorrit Visser[1], Maarten Hulshof[1], Mischa Hoogeman[2], Arjan Bel[1]

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[2]Department of Radiation Oncology, Daniel den Hoed Cancer Center, Erasmus Medical Center, Rotterdam, The Netherlands

For bladder cancer, radiotherapy treatment adaptation by selecting the best plan-of-the-day from a library of plans (created before treatment based on different bladder volumes) is a solution for the observed large interfractional changes. The best plan is selected by visual inspection of the bladder on daily CBCT, while checking adequate boost delivery to the gross tumor volume (GTV) by means of lipiodol markers that are injected around the tumor. Since plan selection is operator dependent, the aim of this study is to investigate the accuracy of semi-automatic plan selection assessed from lipiodol spots.

A five-plan library was generated from two pretreatment CT scans with a full and empty bladder for three patients. To create additional bladder, GTV and lipiodol structures for intermediate bladder volumes (i.e., the library), point-based nonrigid registration was performed between bladder and GTV structures contoured on both CT scans, and the resulting deformation field was scaled (0, 33, 67, 100, 133%). Residual distance error (RDE) was calculated between segmented lipiodol spots on CBCT and the spots in the library, and the minimum was determined. This semi-automatic plan selection was compared to manual plan selection by a radiation technologist for 28 CBCTs.

In 14/28 cases the same plans were selected by the semi-automatic strategy as by manual selection. Overall, minimum RDE was small (3.0+/-1.7 mm), and no significant difference was found with RDE for manually selected plans (3.8+/-2.1 mm).

In conclusion, the semi-automated strategy based on lipiodol distance could aid daily plan selection, while ensuring good tumor coverage.

Paper Number: 0070

FEASIBILITY STUDY ON A MODIFIED VMAT ADAPTIVE RADIOTHERAPY FOR NASOPHARYNGEAL CANCER PATIENTS BASED ON CT-CT IMAGE FUSION

Xiance Jin, Congying Xie, Ce Han

the 1st Affiliated Hospital of Wenzhou Medical College, Wenzhou, China

PURPOSE
To investigate the feasibility of a modified adaptive radiotherapy (ART) by replanning in the initial CT with new contours from a repeat CT at 23rd fraction based on CT-CT image fusion for nasopharyngeal cancer (NPC).

MATERIALS AND METHODS
Dosimetry for replanning volumetric modulated arc radiotherapy (VMAT) plans in the initial CT and in the repeat CT for nine NPC patients was compared. Volumetric and dosimetric changes of gross tumor volume (GTV) and organs at risk (OARs) of this modified ART were further investigated by a deformable registration.

RESULTS
No dosimetric difference between replanning in the initial CT and in the repeat CT was observed. The volume of left and right parotid decreased from 19.91±4.89 cm3 and 21.58±6.16 cm3 in the initial CT to 11.80±2.79 cm3 and 13.29±4.17 cm3 in the repeat CT (both $p<0.01$), respectively. The mean dose and V5 (volume receiving 5 Gy) of left ($p=0.05$, $p=0.01$) and right parotid ($p=0.02$,$p=0.001$) were significantly decreased after replanning. No significant volumetric and dosimetric changes were observed for GTV and other OARs.

CONCLUSION
It is feasible to replanning in the initial CT with new contours from a repeat CT based on CT-CT image fusion, and to ensure safe dose to parotids.

Paper Number: 0136

A STUDY FOR THE IMPLEMENTATION OF DYNAMIC TRACKING RADIOTHERAPY SYSTEM BASED ON TIME SERIES IMAGE PREDICTION METHOD.

Ritu Bhusal Chhatkuli, Kazuyuki Demachi, Hiroshi Sakakibara, Kazuma Kamiaka, Yusuke Nakamura, Mitsuru Uesaka

University of Tokyo, Tokyo, Japan

BACKGROUND

Real-time tumor tracking is significant for the improvement of precision in radiotherapy. However the time lag between the organ in motion and beam delivery causes the beam to miss the target hence prediction during dynamic tracking becomes necessary. Lung tumor undergoes significant deformation during respiration hence both deformation and position should be considered. The tumor motion and deformation can be predicted in the form of time series images, guiding the robotic arm for treatment.

PURPOSE

To predict the future time series images using the images obtained during radiation therapy considering both the tumor position and deformation for implementation of dynamic tracking radiotherapy system.

METHOD

The algorithm includes methods known as principal component analysis (PCA) and multi-channel singular spectral analysis (MSSA). Using PCA, the motion can be denoted as a vector function and it can be estimated by its principal component which is the linear combination of eigenvectors corresponding to the largest eigenvalues.The algorithm includes derivation of principal components and their coefficient using PCA, prediction of future coefficients using MSSA and reconstruction of the future images using PCA.

RESULT

The time series images (movie) were successfully predicted. The calculation time is 0.2secs and the image error obtained is 0.5%. The image correlation factor between the original and predicted is 99% in average in each case.

CONCLUSION

It is feasible to predict the future time series images obtained during radiation therapy in a near real-time. The implementation of this system is believed to be significant for radiotherapy of moving tumors.

Paper Number: 0194

A MASS-WEIGHTED DOSE MAPPING MODEL FOR 4D DOSE CALCULATIONS

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PURPOSE

Respiration induced motion is not negligible for Stereotactic Body Radiation Therapy (SBRT). The intrafractional motion influences the delivered dose distribution on the underlying patient geometry. The quality of any 4D planning procedure strongly depends on the used 4D dose calculation concept. This study introduces a new method for 4D dose transformations on deforming anatomies.

METHODS

The proposed method, called divergent Dose Mapping Model (dDMM), creates dose coordinate transformations taking a mass weighting of single dose points into account. Hence, the dose remodeling after transformation strongly depends on the underlying mass. This study compares the new dDMM approach with certain established models, e.g.: Dose Interpolation Model (DIM), Energy Transfer Method (ETM). The transformation quality is based on the conservation of the dose mass histogram (DMH). Error values are determined by evaluating any DMH modifications.

RESULTS

For evaluation, 900 small sample regions of interest (ROI) are generated inside a 4D respiratory thorax geometry. Dose transformations are performed with dDMM, DIM and ETM. dDMM achieved best measurements regarding the DMH-error in every scenario. The results of dDMM evaluated by statistical values (median, average, quartiles) are at least 3%-5% better than the results of DIM or ETM.

CONCLUSION

dDMM provides a robust solution for numerical 4D dose calculations with low technical effort. In this study, dDMM yielded better results than a selection of established 4D approaches.

ICMP 2013

DAY 3, TRACK 1

CLINICAL IMPACT OF ADVANCED RADIOTHERAPY TECHNIQUES

Invited Speaker

ADVANCED RT TECHNIQUES: ADOPTION THROUGH CLINICAL TRIAL PARTICIPATION

Elizabeth Miles

NCRI Radiotherapy Trials QA Group (RTTQA) Co-ordinator, Radiotherapy Physics, Mount Vernon Hospital, Northwood, Middlesex HA6 2RN

Clinical implementation of advanced radiotherapy techniques is challenging. Trial participation has played a vital role in the adoption of advanced techniques which then become established within routine clinical practice. Frequently, involvement in a clinical trial can be the driver for change in an individual centre. Trial protocols and associated documentation provide the opportunity to implement advanced techniques according to pre-defined outlining, planning and delivery guidelines supporting highly accurate treatment delivery.

The process of an independent QA procedure associated with a trial affords the appropriate support and technical advice to provide confidence, reassurance and safety when implementing a new technique. The results feedback process forms an integral part of any QA programme and serves to offer suggestions for future improvements. In the longer term this process facilitates progress in clinical practice across participating centres.

The quality of clinical trials including a radiotherapy component is increasing in parallel with the growing complexity of RT techniques and increased numbers of patients accrued to trials. A comprehensive QA programme accredits centres for recruitment into these trials benefiting the general standard of radiotherapy delivered in participating centres, improving the quality of treatment and serving to benchmark against national and international standards. On the basis of past experience, it is likely that advanced RT techniques will continue to be introduced via well-designed clinical trials.

Paper Number: 0276

3D TEXTURE ANALYSIS OF PULMONARY CTS: DIFFERENTIATION OF MIXTURES OF PATHOLOGICAL PATTERNS IN THE LUNG

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PURPOSE

Many lung pathologies are mixtures of different pathological patterns which are difficult to be differentiated in CT-data. For example, the superimposition of groundglass and emphysema can fake

honeycombing. Whithin this study it is shown that the use of three-dimensional texture analysis may increase the quality of diagnostic findings in pulmonary CTs due to the better differentiation and quantification of pulmonary disease patterns.

MATERIALS

Retrospectively, 15 thorax CT datasets (0.5 mm slice thickness, native) from 12 patients with different lung diseases (COPD, emphysema, interstitial and granulomatose lung disease, smoke-induced lung disease) were independently analyzed by 2 radiologists with profound experience (5 years, 25 years). Further the same records were examined with the texture analysis algorithm 3D-AMFM (Adaptive Multiple Feature Method) , analyzing CT-data via previously trained disease-specific pathological parenchymal textures (normal, groundglass, honeycombing, emphysema, nodular, tree-in-bud).

RESULTS

92 percent of known lung pathologies were clearly identified by 3D-AMFM. 11 out of 15 cases texture analysis delivered relevant additional information: Mixtures of pathologies could unequivocally be

differentiated and confirmed by a second analysis. Mixtures of emphysema and groundglass could be detected in all cases. In 2 cases mixtures of honeycombing and groundglass could be quantified.

CONCLUSIONS

The disadvantage of the method presented is the absence of a ground truth but seems to be capable to be employed in the separation, differentiation and extent of several pathological patterns.

3D texture analysis can support the radiologist in the interpretation and differentiation of mixed pathological parenchymal patterns.

Paper Number: 0184

CONSTANT DOSE-RATE VMAT (VOLUMETRIC MODULATED ARC THERAPY) IS A SUITABLE TECHNIQUE FOR APICAL LUNG TUMOURS

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OBJECTIVES
The purpose of this study was to establish whether constant dose-rate (CDR) VMAT is a suitable technique for apical lung tumours.

METHODS
Five apical lung tumour patients had their treatment retrospectively re-planned using three VMAT techniques: variable dose-rate (VDR) VMAT planned in both Eclipse (RapidArcTM) and Pinnacle3 (SmartArcTM), and CDR-VMAT planned in Pinnacle3. VDR-VMAT requires a VMAT-enabled linac; CDR-VMAT plans can be delivered using conventional linacs. The plans were assessed using clinical constraints for targets and normal tissues. The Delta4 phantom was used to compare the dosimetric accuracy of delivery for each technique.

RESULTS
All three techniques produced plans that met clinical criteria for planning target volume coverage and organ-at-risk doses. On average, Eclipse plans used 721 monitor units compared with 398 for Pinnacle3 VDR-VMAT and 387 for CDR-VMAT; the Eclipse value was significantly higher than for the Pinnacle plans ($p<0.001$). Averaged across all patients, the median dose deviation between plan and measurement was -0.3% for CDR-VMAT, 0.2% for VDR-VMAT planned in Eclipse and -1.2% for VDR-VMAT planned in Pinnacle3. The average pass rate for the γ (2%, 2mm) test was 100% for CDR-VMAT, compared to 99.9% for VDR-VMAT planned in Eclipse and 96.4% for VDR-VMAT planned in Pinnacle3. When CDR-VMAT delivery time was minimised to match VDR-VMAT, the median dose deviation measured -0.9%, and the γ (2%, 2mm) pass rate decreased to 98.5%.

CONCLUSIONS
CDR-VMAT offers a suitable alternative to VDR-VMAT for the apical lung site.

Paper Number: 0275

PENUMBRAL BOOSTING IN IMRT LUNG PLANNING

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Inverse-planned direct machine parameter optimisation (DMPO) fields or VMAT treatments have the ability to streamline the planning and treatment process and improve conformality of the dose distribution, compared with 3D conformal radiotherapy techniques. A potential problem with inverse planning is that when part of the target comprises low density tissue such as lung the optimiser may attempt to boost the fluence to these regions. If movement causes the CTV to move into a boosted region it will be exposed to higher doses than desired. Overriding the density of the PTV in air at the optimisation stage, followed by the final calculation using the real density map, has been suggested as a method to overcome this problem.

This work compares five planning methods for three lung patients: forward planned with static fields, DMPO static fields optimised both without and with density overrides on the PTV in air, and VMAT optimised both without and with density overrides on the PTV in air. Plan robustness has been tested by shifting plans by the PTV margin (0.9cm) in 6 cardinal directions and recording the maximum dose to the plan and the V95 for the CTV. The average maximum increases in maximum dose found are 2.8%, 2.2%, 2.5%, 1.8% and 2.9% for the original, VMAT with and without density override and DMPO with and without density override respectively.

We conclude that our relatively conservative planning parameters have limited the penumbral boosting effect. A greater difference between the planning techniques is expected for more modulated treatments.

Paper Number: 0141

COMPUTER SIMULATION OF THE RESPIRATORY INTERPLAY EFFECT IN HELICAL TOMOTHERAPY PLANS: BASELINE VARIATION EFFECTS CAN SIGNIFICANTLY OUTWEIGH THOSE OF CYCLIC RESPIRATORY MOTION

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A programme has been developed to use respiratory traces obtained from the Varian RPM system to study the impact of longitudinal respiratory motion on the robustness of tomotherapy plans. It is based on CheckTomo, an independent dose-calculation system for helical tomotherapy, with finer spatial resolution, and with the timing of couch position, MLC opening and gantry position implemented on sub-projection timescales.

The respiratory traces of three patients have been applied to three phantom plans; each of different field width and pitch. The mean peak-to-peak amplitude of the respiratory motion was set to a range of values up to 2.5cm. Each patient's respiratory trace was additionally divided into a baseline variation and a cyclic component, with each partial-trace used on separate simulations. The dose distribution to the central slices of the PTV were analysed for evidence of the interplay effect, quantifying the standard deviation of voxel doses, and the proportion of voxels with doses more than 5%, 10%, 15% and 20% greater or less than the required dose.

The differences in single-fraction dose from planned varies with the respiratory amplitude, typically being larger for greater amplitude. The shape and magnitude of the dose differences were found to be strongly dependent on the respiratory trace used. Considering cyclic motion only, the maximum underdose and overdose averaged 5.9% and 5.0%. Including baseline shifts, this became 12.3% and 22.8%, with 16% of the voxels having <90% of planned dose, and 47% having >110% . One extreme case showed a maximum overdose of 33%.

Paper Number: 0089

A COMPARISON OF FFF VERSUS FLATTENED MODES WITH HD AND STANDARD MLC'S TO DELIVER SRS UTILISING VMAT

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OBJECTIVE

To compare plan quality in terms of dosimetric homogeneity, target conformity, organ-at- risk (OAR) sparing, monitor unit (MU) usage, and beam-on time for eleven stereotactic radiosurgery patients using RapidArcTM volumetric- modulated arc therapy (VMAT) with both standard and flattening filter free modes. Plans were calculated with both a standard 120 leaf MLC and a HD120 MLC.

METHOD

Eleven patients with 1 or more brain metastases underwent CT simulation. Treatments were planned using Varian Eclipse TM v10.0.39 to generate four 2-arc RapidArc plans delivering the same dose to the PTV (FFF and flattened mode with standard and HD120 MLC). Plans were created with dose control tuning structures surrounding targets to maximize conformity. Dosimetric parameters used for analysis were RTOG conformity index (CIRTOG), homogeneity index (HIRTOG), inverse Paddick Conformity Index (PCI) and D5-D95. OAR sparing was analyzed with Dmax and D10cc for Brain. Treatment delivery was evaluated using beam-on times for a Varian Truebeam, Varian Truebeam STx and Varian Clinac iX.

RESULTS

Dosimetric conformity, homogeneity, and OAR sparing were comparable with the HDMLC, irrespective of mode. The PCI was inferior for the standard MLC plans with the mean decreasing from 4.3(±1.2) to 3.8(± 0.7). The PTV homogeneity index was also inferior for the standard MLC, decreasing from 3.3(± 0.8) to 2.4(± 0.7). Mean beam-on times for FFF mode and flattened mode were 3(±0.7) and 12(±2.4) minutes, respectively. Mean MUs were 6760 and 7015, respectively. This improved workflow limits the potential for intrafraction organ and patient motion, reducing dosimetric errors.

Paper Number: 0172

CLINICAL INVESTIGATION OF INTER SEED ATTENUATION AND TISSUE COMPOSITION EFFECTS IN PROSTATE I-125 SEED IMPLANT BRACHYTHERAPY.

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INTRODUCTION

In permanent seed implant prostate brachytherapy the actual dose delivered to the patient may be less than that calculated by TG43-U1 due to inter-seed attenuation (ISA) and differences between prostate tissue composition and water.

METHOD

Monte Carlo simulations of ultrasound based pre-plans and CT based post-plans were performed for 30 patients using tissue models recommended by TG-186. Simulation results were compared to TG43-U1 using DVH parameters for the prostate, urethra and rectum. Sector analysis of ISA effects was performed dividing the prostate into 12 segments.

RESULTS

For CT post-plans, the mean effect of ISA and tissue was to reduce prostate D90 by 3.9Gy (2.7%), prostate V100 by 0.5cc (1.4%), urethra D10 by 9.6Gy (3.9%), rectal D2cc by 5.0Gy (4.5%). For ultrasound pre-plans the mean effect was smaller, reducing prostate D90 by 2.0% and V100 by 0.1cc. Sector analysis showed that in CT post-plans the majority of points where ISA causes prostate dose to fall below 100% are near the prostate base however this is not true for ultrasound pre-plans as these have more uniform coverage and seed spacing.

CONCLUSIONS

ISA and tissue composition effects cause the delivered dose in prostate seed implant brachytherapy to be lower than that calculated by TG43-U1, although the impact on DVH parameters is small. For this group of patients the effect is largest at the prostate base, which is already an area that is commonly underdosed in prostate seed brachytherapy.

ICMP 2013

DAY 3, TRACK 2

CT LOWERING THE DOSE EXPANDING THE APPS

Invited Speaker

SUB-MSV CT – PROSPECTS FOR TURNING IT INTO REALITY

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In general, optimisation aims at maximising the benefit of a procedure while at the same time minimising potential risks or side effects. For x-ray computed tomography (CT), this means that patient dose should be kept to the minimum necessary for adequate image quality. The aim of this lecture is to focus on options for reducing patient dose without impairing image quality.

Dose levels in CT today are typically quoted at 1 to 15 mSv effective dose per CT scan and will depend on the exam and on the anatomic range examined. The underlying dosimetry issues will be discussed briefly.

Modern CT scanners offer a variety of means for reducing dose without a detriment in image quality. The availability of voltage values below the standard 120 kV setting is one of the most important steps. Model-based iterative image reconstruction, dedicated filtration, tube current modulation and automated exposure control are further examples which will be discussed. These measures have to be complemented by proper assessment of dose and by providing the respective information to the user on the console; respective tools will be presented.

The current trend is to bring dose for CT in general, and particularly for paediatric CT, down to the sub-mSv range and thereby to increase the benefit-to-risk ratio further: “As high as reasonably achievable” or AHARA is the goal regarding this ratio.

Invited Speaker

ITERATIVE RECONSTRUCTION: METHODS, IMAGE QUALITY AND PATIENT DOSE

Nicholas Keat

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Throughout nearly all of the clinical history of CT, image reconstruction from raw data has been based upon analytic filtered back projection (FBP) techniques. Whilst these methods have advantages in terms of (relative) computational simplicity and linearity, another class of reconstruction techniques have recently gained ground due to a number of practical advantages combined with increased computer power to enable them to be used in routine clinical practice.

Iterative reconstruction involves the repeated application of a process that compares the measured CT attenuation data with those simulated from a forward projection of the current version of the image. From this comparison, a correction image can be applied to generate the next version of the image which is more consistent with the measured data. Through appropriate tuning of the updates, the iterative algorithm can be made to converge upon on a 'best' solution. The advantages of these images depend upon the sophistication of the forward projection technique, but image noise is typically reduced compared to FBP, without a loss of spatial resolution. When the geometry of the scanner, including the x-ray tube focal spot and detectors are modelled, there is the potential for improvements in spatial resolution and reduction of cone beam artefacts. Modelling photon interactions such as scatter and the effect of beam hardening are also possible, but have the potential to improve image quality further. With the improvement in image quality for given scan parameters, there is also the potential to reduce patient radiation dose without compromising clinical diagnostic value.

Invited Speaker

PHOTON COUNTING SPECTRAL CT WITH A SILICON STRIP DETECTOR

Mats Danielsson

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Silicon strip detector with sub-millimeter pixel size operated in single photon-counting mode has been developed for use in spectral computed tomography (CT). Edge-on geometry is adopted to obtain a high detection efficiency for silicon for the spectrum used in conventional CT imaging. A fast application specific integrated circuit (ASIC) specially designed for fast photon-counting application is used to process the pulses. The energy of each event is obtained by comparing with 8 separate thresholds. We will present measurements on the ASIC as well as the module levels and compare to simulations. Also we will show first images and discuss sensitivity to ring-artifact and stability with regards to count-rate, radiation dose and temperature. We will also discuss the integration and planned tests in a state-of-the-art CT gantry and clinical applications for spectral CT.

Paper Number: 0077

COMPUTERIZED MEASUREMENT OF MUCOSAL INFLAMMATION CHANGE

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PURPOSE

Chronic rhinosinusitis is an inflammatory disease of the mucosa that substantially impacts quality of life. Previous studies indicate that increased inflammation is associated with decreased quality-of-life scores; however, quantitative analysis is currently impractical because manual volume outlines take ~1-1.5hrs per scan. A computerized method was developed to accurately quantify change in mucosal inflammation while reducing observer time-cost.

METHODS AND MATERIALS

The computerized method consists of registration, temporal subtraction, segmentation, and manual refinement steps. Two otolaryngologists manually outlined mucosal inflammation change between sequential CT scans of 13 chronic rhinosinusitis patients. Manual delineations were used as the gold-standard. Accuracy and precision were quantified using Bland-Altman analysis and observer time-cost associated with the computerized methods was recorded.

RESULTS

The average bias between observer-created and the computer-created outlines was -47.63mm2 (median: -1.76mm2) and the 95% confidence interval was [-201.6mm2, 296.86mm2]. The time to delineate all mucosal inflammation change was 28 seconds per scan. Semi-automated correction improved the average bias by 55.8% and the 95% confidence interval by 41.3%. Errors primarily occured in the nasal passage. The average observer time-cost was 1.48 minutes per scan using semi-automated correction.

CONCLUSION

The computerized method substantially reduced the observer time-cost associated with quantitative analysis of mucosal inflammation change. This computerized method represents the first step in the creation of a system for the quantitative 3D analysis of chronic rhinosinusitis.

Paper Number: 0167

EVALUATION OF LUNG CT CAD PERFORMANCE BY USING PSF-BASED VIRTUAL NODULES: A VALIDATION OF THE METHODOLOGY

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The National Lung Cancer Trial (NLST) has demonstrated that the low-dose CT screening saved lives from lung cancer. On the wide implementation of CT screening, computer aided diagnosis (CAD) is expected to play the key role for the accurate screening. Although optimal use of CAD can only reach with efficient performances of the system, there is no accredited method available for detail evaluation of CAD performance. Therefore, we have proposed point spread function (PSF)-based virtual nodules for that. Aim of this study is to validate the application of PSF-based virtual nodules for evaluation of performance of lung CT CAD.

Computer simulation was done based on PSF measured in CT systems to generate virtual nodules. Firstly, virtual nodules with similar characteristics of artificial nodules set in the phantom were fused on anthropomorphic chest phantom images. CAD outputs were taken and the detections of artificial nodules and virtual nodules were compared. In the next part virtual nodules of different densities and sizes were fused on images of two separate groups of five subjects from a lung screening clinic. CAD detections were analyzed by jackknife method for the FROC of each group.

Phantom study shows a good agreement (96%) between CAD detections of artificial and virtual nodules. The statistical analysis of FROC has shown similar dependency of CAD performances for both groups on nodule size or density.

These studies verify the validity of application of PSF-based virtual nodules to evaluate lung CT CAD performance in detail.

Paper Number: 0173

COMPUTED TOMOGRAPHY DUAL ENERGY ANALYSIS FOR THE ASSESSMENT OF THE 3D SPATIAL DISTRIBUTION OF THE CA/P RATIO IN BONE MINERAL CONTENT

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The understanding, diagnosis and prevention of osteoporosis may be enhanced if the chemical factors of bone which affect its load-bearing capability are studied. Previous studies have shown that there is a relation between osteoporosis and a lowered and non-homogeneously distributed ratio in cortical bone of two of its main constituents, Calcium and Phosphorus. To further investigate this relation a technique was developed for the non-invasive assessment of the 3D spatial distribution of the Ca/P ratio in bone.

Computed tomography dual energy analysis (CT-DEA), a subtraction imaging quantification technique, was developed and optimised for the assessment of the 3D spatial distribution of Ca/P ratio in bone. Ten bone phantoms of known Ca/P ratio were imaged using an X-Tek micro-computed tomography system to obtain the experimental validation of the technique. Furthermore, 3 healthy and 3 inflammation-mediated osteoporotic collagen-free rabbit bones were imaged to assess the performance of the technique in identifying osteoporosis in real bone mineral content.

Measurements of Ca/P ratio in synthesised bone validated the technique. Measurements in rabbit bone have shown that there is a relation of low and non- homogeneously distributed Ca/P ratio and osteoporosis, showing the ability of the technique to successfully identify osteoporosis in bone, in-vitro.

The proposed technique is a promising tool to study the significance of Ca/P ratio in osteoporosis. This is currently under validation by comparison with mechanical testing, and could in the long term lead to the development of a new diagnostic tool.

ICMP 2013

DAY 3, TRACK 2

SMALL FIELD DOSIMETRY WORKSHOP

Invited Speaker

SMALL FIELD DOSIMETRY: STATE OF THE ART AND FORMALISING CURRENT PRACTICE

Hugo Palmans

National Physical Laboratory, United Kingdom

The increased use of small photon fields in stereotactic and intensity modulated radiotherapy has raised the need for standardizing the dosimetry of such fields using procedures consistent with those for conventional radiotherapy. An international working group, established by the IAEA in collaboration with AAPM and IPEM, is finalising a Code of Practice for the dosimetry of small static photon fields.

While many problems of small field dosimetry have been raised, e.g. in IPEM Report 103, a vast amount of literature has addressed most of those and proposed solutions (often for specific situations though). The reported problems include the definition of field size, the field size dependent response of detectors, volume averaging, fluence perturbation corrections, reference conditions and beam quality in non-conventional reference fields. One area of importance for establishing a code of practice is the availability of data and this happens to be a dynamic area in which many papers have been published recently with new data or insights that enhance our understanding of small field dosimetry substantially.

This presentation will review the present understanding and solutions for small field dosimetry, the formalisms that have been proposed to provide practical procedures for small field dosimetry and compilations of available data from the literature.

Invited Speaker

THE PHYSICS AND CHALLENGES OF SMALL MV PHOTON BEAMS

Paolo Francescon

Medical Physics Department, "San Bortolo" Hospital, Vicenza Italy

In modern radiation therapy small megavoltage (MV) photon fields of dimensions less than 3.cm ×3.cm are being used increasingly. The clinical physicist is faced with several challenges in the dosimetry of small MV photon fields. These primarily arise because of the occlusion of the direct photon beam source at small collimator settings and the lack of lateral charge particle equilibrium (CPE). The dosimetry due to the lack of CPE is further complicated at the presence of low-density media, such as lung or air, in the irradiation geometry. Therefore a major challenge is the choice of appropriate detector for dosimetric measurements in terms of size and construction, because, depending on beam energy, at small field sizes the dose varies significantly from the central axis to the periphery of the field and most detectors available in clinics are simply too large to resolve the beam profile and penumbra in such small fields. To a lesser extent, variations in radiological parameters due changes in particle spectrum with decreasing field size also pose considerations. Numerous experimental studies and Monte Carlo (MC) simulations have been performed to investigate the suitability of the various types of detectors in the measurement of depth functions (percentage depth doses (PDD), tissue maximum ratios (TMR), tissue phantom ratios (TPR)) and field size factors (output factors) in small photon fields. A general conclusion has been that the detector used to measure the absorbed dose on the central axis should be considerably smaller than the beam radius when lateral electron equilibrium is not established.

ICMP 2013

DAY 3, TRACK 2

NUCLEAR EMERGENCIES WORKSHOP

Invited Speaker

CHALLENGES OF THE MEDICAL PHYSICIST IN PREPAREDNESS FOR AND IN RESPONSE TO EVENTS OF NUCLEAR OR RADIOLOGICAL EMERGENCY

Fridtjof Nuesslin

Technische Universität München

Actually before the Fukushima accident management of radiation emergencies have been hardly in the focus of the medical physicist's daily life. That event however raised the debate on the role of medical physicists in scenarios of nuclear and radiological emergencies (NRE). Since then several publications and meetings (e.g. World Congress 2012 in Beijing) emphasized the potential role of medical physicists who are among the most knowledgeable individuals. They are experienced in issues of radiation exposure, dose measurement, risk assessment, radioactive contamination, etc. As health care professionals medical physicists are widely familiar with aspects of radiation protection and capable to assess and communicate the consequences of a radiation emergency event. Hence, jointly with the IAEA and the WHO discussions have been initiated to prepare guidance for medical physicists on their role in NREs, in particular to design adequate training. Furthermore, governments have to be addressed to consider medical physicists as a professional resource in NRE. This workshop aims to review current concepts and regulations of management of NREs already set in force in various countries and to discuss specific guidelines for medical physicists in events of NRE. The final roundtable shall outline further actions to improve preparedness of medical physicists for events of NRE.

Invited Speaker

EMERGENCY EXPOSURE SITUATION AND EMERGENCY MANAGEMENT

E. Buglova, V. Kutkov and T. McKenna

Incident and Emergency Centre, Department of Nuclear Safety and Security, International Atomic Energy Agency

The Incident and Emergency Centre (IEC) of the International Atomic Emergency Agency (IAEA) is the global focal point for preparedness and response to nuclear and radiological incidents and emergencies irrespective of their cause. In the area of preparedness the Centre continuously works to develop standards and guidance for strengthening Member States' preparedness; practical tools and training programs to assist Member States in promptly applying the standards and guidance; and organizes a variety of training events and exercises. Lessons learned from responses to past events have shown that more guidance is needed for the use of radiation protection dosimetry framework in response to nuclear or radiological emergency. The IAEA systematically revises dosimetric basis and criteria for use in preparedness and response to emergencies with objective to provide optimized protection of the emergency workers and the public in emergency exposure situation. This report briefly describes the approach used to develop the basis for emergency response criteria for protective actions to prevent severe health effects in the case of external exposure and intake of radioactive material. Special attention is put for use of medical physicists and other specialists with background in nuclear and radiation physics implementation of the last IAEA publication "Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor" (EPR-NPP PUBLIC PROTECTIVE ACTIONS, IAEA, Vienna, 2013).

Invited Speaker

EMERGENCY EXPOSURE SITUATIONS: HANDLING AND TREATMENT OF CONTAMINATED AND IRRADIATED CASUALTIES: CHALLENGES FOR THE MEDICAL PHYSICIST

Hugh Wilkins

Medical Physics Department, Royal Devon and Exeter Hospital, UK

There are various scenarios in which health systems may receive casualties potentially contaminated with radioactivity and/or having sustained significant exposure to radiation. Such events are infrequent and each has unique aspects. Such scenarios place substantial burdens on healthcare organisations affected and may create significant challenges for medical physicists.

Hospital physicists will generally be familiar with issues arising from medical exposures to radiation. Their theoretical and practical knowledge will include radiation dose quantities and units, concepts which are fundamental to an understanding of levels of radiation risk. Moreover they are likely to be experienced in communication of radiation risks. Those working in nuclear medicine will be familiar with issues arising from administration of radioactive substances to patients, which can provide valuable perspective in emergency situations. They are likely to have access to radiation detection equipment and a network of colleagues who may be able to assist if further resources are required. Physicists are involved in quantitation of in-vivo radioactivity and dose calculations which are likely to play a significant role in casualty management.

This talk will describe experience with the setting up and operation of a temporary radiation monitoring unit during an emergency planning exercise for a large nuclear site. 333 role-playing ‘evacuees’ were monitored by pre-positioned teams using a two-stage monitoring strategy described by an observer as groundbreaking. It will outline current UK policy for dealing with health aspects of nuclear and radiological incidents, discuss ways in which medical physicists can contribute and suggest challenges they are likely to face.

Invited Speaker

EMERGENCY PREPAREDNESS: EDUCATION AND TRAINING OF MEDICAL PHYSICISTS IN SWEDEN

Mats Isaksson, prof.

The Sahlgrenska Academy, Institute of Clinical Sciences, Department of Radiation Physics, University of Gothenburg, Sweden

The role of the medical physicist has been recognized by several Swedish authorities, mainly the Swedish Radiation Safety Authority (SSM), The National Board of Health and Welfare (SoS) and the Swedish Civil Contingencies Agency (MSB). By initiative from SSM, part of the Swedish budgetary allocation for emergency preparedness is used to finance three university positions for development of courses and exercises in emergency radiation protection. The grants are also available to cover the expenses of the courses below.

The courses were mainly aimed at medical physicists working at Swedish hospitals and were from the start given as part of the system of Continuous Professional Development (CPD), administered by the Swedish union of medical physicists. They have then been used as a basis for the master courses given since fall 2012. The courses presently given within the CPD-program are Emergency preparedness and radiation protection in radiological and nuclear situations; Radiation protection in medical emergency preparedness; Detectors and measurement methods in radiation protection and emergency preparedness; and Radiation protection and environmental impact of the nuclear fuel cycle.

Two courses are given every second year during three days, which enables us to gather the Swedish experts in different areas as teachers. The exams are often in the form of essays that will make the participants to scrutinize the emergency preparedness at their home hospitals.

NUCLEAR EMERGENCY MANAGEMENT SYSTEMS IN SOUTH AFRICA

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There are two nuclear radiation facilities in the Western Cape, South Africa, namely (1) Koeberg Nuclear Power Plant, consisting of two identical 940 MW pressurized water reactors and (2) iThemba Labs, a national accelerator centre and radionuclide production facility with a 200 MeV Separated Sector Cyclotron.

Advice on the medical management of patients during a nuclear emergency will be managed by the Radiation Emergency Medical Advisory Centre of South Africa (REMACSA) which was launched in 2005. The mission of REMACSA is to establish a functional preparedness facility for the management of patients exposed to high doses of ionising radiation. Some of the objectives of REMACSA are to train professionals in radiation emergency management, conduct emergency exercises and establish a 24 hour contact point for nuclear accidents.

In addition, Tygerberg Hospital has an established radiation casualty facility. This was developed for the medical management of contaminated individuals who also require acute medical attention.

Koeberg Nuclear Power Plant has a comprehensive set of Emergency Planning procedures to handle nuclear emergencies. The emergency plan contains protective actions that include sheltering, evacuation, thyroid protection, analysis and control of food materials and decontamination of individuals.

iThemba Labs has a biodosimetry facility which houses an intelligent microscope that is used for internal radiation dosimetry.

The presentation will describe the activities of REMACSA and the facilities available for the management of radiological emergencies in South Africa.

Invited Speaker

REVIEW OF THE JSMP FUKUSHIMA SURVEYS. CHALLENGES TO MEDICAL PHYSICISTS IN JAPAN

Akifumi Fukumura

National Institute of Radiological Sciences (NIRS), Chiba, Japan

Since the Fukushima nuclear accident the Japanese government, local governments in Fukushima Prefecture and related bodies such as NIRS have struggled against the difficult situations. Also, some of Japanese medical physicists were involved in support for evacuation and inspection of radioactive contamination etc. soon after the accident.

One year after the accident, Japan Society of Medical Physics (JSMP) carried out the survey for the JSMP members to obtain information on activities and role of medical physicists for the accident. The principal results of the survey are as follows;

I. The 43 % of respondents were involved in activities related to the accidents.

II. The principal activities were

1) risk communication to the public,

2) RI contamination survey for residents and

3) radioactivity measurements in environment.

III. The respondents thought that medical physicists shall contribute to

1) risk communication to the public and

2) preparation of FAQ and/or material.

There are still residents who fear the effect of low dose radiation excessively. Although evacuation area is limited, 53,960 residents of Fukushima prefecture were still evacuated to other prefectures as of the 6th June 2013.

It seems not so easy for experts who promoted nuclear energy to take care of the residents. Some of the residents think of future health of their children or refusal to be exposed to X-ray in a hospital. The risk communication to the public is quite important and then medical physicists have been expected to carry out an important role as one of experts.

This presentation will review the JSMP survey and propose the role expected to medical physicists in nuclear emergency, including some of the author's experience after the accident.

Invited Speaker

IAEA PROJECTS AND SUPPORT FOR AFRICA

Ahmed Meghzifene

Section Head, Dosimetry and Medical Radiation Physics , IAEA

The International Atomic Energy Agency (IAEA) has a mandate “to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world”. Through its Human Health Programme, the IAEA develops guidance documents on standards of practice in radiation medicine and provides support to its Member States for establishing and upgrading their infrastructure. In the area of medical physics, the IAEA has a wide range of initiatives to support capacity building, implementation of internationally harmonized dosimetry protocols and Quality Assurance (QA) guidelines, and the provision of external peer-reviews for quality improvement purposes. In addition, the IAEA support its Member States to establish or upgrade their radiation medicine infrastructure, through its technical cooperation programme.

In the past, the IAEA support to African Member States aimed mainly at setting up the first radiotherapy centre in the country, followed by projects focussing on dosimetry equipment, QA and support for equipment commissioning. In the recent years, the scope of IAEA support has widened to include transitioning to new and sustainable imaging and radiotherapy treatment modalities and high dose rate brachytherapy. In the area of education and training, IAEA efforts continue to focus on the harmonization of education and clinical training requirements and supporting the establishment of national education programme in medical radiation physics. In this context, the IAEA is in the process of identifying regional academic and clinical training centres in Africa. Finally, the IAEA has facilitated the establishment of the Federation of African Medical Physics Organisations through its regional technical cooperation on medical radiation physics.

Invited Speaker

RADIATION EMERGENCY- THE ROLE OF MEDICAL PHYSICISTS

Kin-Yin Cheung, Ph.D., President, IOMP

Hong Kong Sanatorium & Hospital, Hong Kong

Medical physicists (MP) are educated and trained to support patient management in hospitals using radiation. Most of them are trained to handle hospital radiation emergencies involving, e.g. radiation contamination of workplace and persons. Depending on individual countries, some MP are trained to support management of casualties contaminated with radioactive substances from major nuclear accident. They are familiar with the procedures and equipment used in radiation survey and dose monitoring, decontamination, identification of radioisotopes, shielding and safe management of radioactive substances. In major radiation emergency, e.g. accident in nuclear power plant involving release of radioisotopes and contaminated casualties, MP can be mobilized to support the management of such casualties admitted to hospitals and if necessary provide support at decontamination centres for the non-injured. All MP in countries where nuclear facilities are in place should be trained to provide the required services in case of radiation emergency. National health, rescue, and security authorities should, in consultation with medical physics organizations, take into account the potential resources of MP and the services they can provide in planning major radiation emergencies and decontamination facilities. MP engaged in such emergency plans should be familiar with the plans and procedures, communication protocols, and particulars of the emergency equipment and materials. They should maintain the functionality of the equipment and perform emergency drill regularly.

ICMP 2013

DAY 3, TRACK 2

NEW HORIZONS IN DIAGNOSTIC RADIOLOGY

Paper Number: 0087

CAN PHASE-CONTRAST BE PRODUCED USING A CONVENTIONAL DIAGNOSTIC X-RAY SOURCE?

Rebecca Gillen[1], Kevin Robson[1], John Kotre[1], Andrew Davies[2]

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OBJECTIVES

At boundaries between materials of differing refractive indices, phase effects can produce edge-enhancement without increasing noise. This can improve the perceived quality of X-ray images.

Phase contrast enhancement using X-ray beams of energies typically used in diagnostic imaging has previously been explored using microfocus sources. Small focal spots make phase contrast more readily observable. This study used a conventional X-ray set with a larger focal spot.

METHODS

A Perspex test object was used with a range of imaging geometries, using four different energies.

Two sets of images were taken: one set using imaging geometries allowing phase contrast to be observed and a comparison set using imaging geometries for which phase effects were negligible. Images with the same magnification from different sets were compared.

The edge-enhancement effect was quantified by measuring the width of the edge profile, specifically, the distance between the 90% and 10% detected dose levels.

RESULTS

Increased magnification incurs blurring and hence widens the edge profile. Due to the relatively large focal spot, images were susceptible to blur. The edge profile was narrower for images where phase effects were present for all magnifications. This suggests that edge-enhancement due to phase contrast counteracts geometrical blurring. The profile width decreased by 30-50% for most configurations.

The extent of edge-enhancement varied with imaging geometry. Observed trends agreed with previous research. Edge-enhancement increased with decreasing energy.

CONCLUSIONS

Subtle phase contrast effects were found using a conventional diagnostic X-ray set. Further research may allow phase contrast techniques to be used clinically.

Paper Number: 0347

CREATION OF PATIENT-MIMICKING PHANTOMS USING A 3D PRINTER

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INTRODUCTION

In quality assurance of x-ray systems technical phantoms are used to ensure optimal functionality of the x-ray equipment. However, it is criticized that technical phantoms do not relate to real patient structure, e.g. the shape of structures is different. Therefore it would be helpful using phantoms which correspond to real patients. A simple method, which uses patient images and 3D printer to generate phantoms, is shown and initial results are presented.

MATERIAL AND METHODS

Digital mammograms from clinical settings were used in this study. The absorption information in the images are used in the 3D print of the phantoms. The height of the printed 3D structure corresponds to the absorption in the image. Using images with subtle lesions phantoms with difficult detection tasks were generated. The printed phantom was used in x-ray imaging and the generated images compared with the initial images.

RESULTS

The images of the phantom correspond well with the original image. Due to the sampling and resolution in the 3D print, the images look slightly blurred, compared to the original image. The difficult detection tasks in the original images are reproduced in the images obtained with the generated phantoms.

DISCUSSION

A new and simple method is presented, which enables the use of clinical images to generate new types of reproducible phantoms. The x-ray images of those mimic patient structures and might include subtle lesions. These phantom can be used for quality assurance tasks.

Paper Number: 0047

CORRELATION BETWEEN CAROTID INTIMA-MEDIA THICKNESS, INTERNAL CAROTID ARTERIAL RESISTIVE, AND PULSATILITY INDICES IN PATIENTS WITH TYPE 2 DIABETIC.

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ABSTRACT

Patients with type 2 diabetes mellitus are at a high risk for developing atherosclerosis and coronary heart disease. Intima-media thickness (IMT) of the common carotid (CCIMT) artery, resistive (RI) and pulsatility (PI) indices of the internal carotid arteries are employed as a reflector of vascular thickness, and stiffness respectively.

THE AIM

To examine the possible correlation between the CCIMT and RI, PI of the internal carotid artery in type 2 diabetics patients.

MATERIALS & METHODS

B-mode ultrasound is used on 100 patients with exemption of any cardiovascular disease, and 40 normal volunteers. Patients group was divided into four groups: (1) diabetic patients, (2) diabetic with hypertension, (3) diabetic with dyslipidemia, (4) diabetic with hypertension and dyslipidemia.

RESULTS

The mean of CCIMT, RI, and PI on both sides in patient groups are generally higher than control.

No significant correlation between CCIMT, RI, and PI are found with exception of the left CCIMT and left PI ($r= 0.4$, $P= 0.05$) in group (3). The left CCIMT is associated with left end-diastolic velocity (EDV), and peak systolic velocity (PSV) ($r = -0.43$ $P=0.007$, $r = -0.32$ $P= 0.049$ consequently).

A significant correlation is found regarding (FPG) with RI, and PI on both left and right sides ($P< 0.05$) in group (4). This relation is limited to the right side only with (PSV), and (EDV) in group (2) ($P< 0.05$).

CONCLUSION

IMT, RI, and PI information can demonstrate the severity of vascular diseases. But still there is no definite correlation between them.

Paper Number: 0289

3D PDF AS VERSATILE INTERFACE IN PRE-OPRATIVE PLANNING

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PURPOSE

3D PDF is a format that allows for interactive 3D representation including zoom, colouring, rotation and other features of surface files within the popular Acrobat Reader. Furthermore the PDF format can be stored in commercial PACS systems and allows for digital signature. We utilized this type of communication for pre-oprative planning of orbita fracture cases.

METHODS

CT-Data of patients with orbital fracture were segmented by various methods such as threshold level set and atlas-based algorithms. The individual anatomical regions were selected and converted into surface files such as STL. Additional calculations regarding volume, distances, angles, view angle axes were performed and as overlays implemented.

RESULTS

The multi-platform access of interactive 3D reconstructions including anatomical morphology, measurements and related information can summarized in one password and digital signature protected report. The file size is small enough to deliver via e-mail for second opinion in respect to patient related data safety.

CONCLUSION

3d-PDF is a powerful platform independent pre-oprative planning device that was broadly accepted by maxillo-facial surgeons. Other anatomical regions for adapting 3D-PDF are currently under investigation.

Paper Number: 0320

MEDICAL IMAGING SYSTEM DESIGN USING A MO TRIBOELECTRIC X-RAY SOURCE.

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A proposed model of a triboelectric x-ray source imaging system has been analyzed and corrected to provide a better quality regarding the intensity and penetration of the X-ray beam obtained under specific vacuum conditions that allow the triboelectric effect to produce characteristic X-rays.

On previous works the characterization of a triboelectric X-ray spectrum was analyzed in terms of the spectra penetration, it was concluded that such source of X-rays has enough penetration to obtain an X-ray medical image and due to its low voltage system design, it has been proposed for soft tissue diagnosis imaging, because of their similar voltage applied and Half Value Layer (HVL) needed compared to a conventional X-ray tube used for mammography.

A prototype of a vacuum chamber wherein the X-ray source is contained and an electronic radiation detector circuit have been built. Regarding those specifications, different corrections have been computed related to the attenuation of the particles. The attenuation corrections that were made to the system using data from a triboelectric spectra and compared with Mo tube spectra (Oxford Instruments, Apogee 5000) included the 6 mm. acrylic wall of the vacuum chamber, the inverse square law for the air distance between the X-ray source and the objective at 10 and 15 cm., furthermore, attenuation computations for different materials were made, being soft tissue, water molecules and bone, at different depths of 1, 3, and 5 centimeters of penetration.

Paper Number: 0350

EVALUATION OF CT ITERATIVE RECONSTRUCTION ALGORITHM (SAFIRE) AND COMPARISON WITH FILTERED BACK PROJECTION USING AMERICAN COLLEGE OF RADIOLOGY CT ACCREDITATION PHANTOM

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PURPOSE
To evaluate iterative reconstruction algorithm (SAFIRE) and compare performance with Filtration Back-Projection (FBP) using ACR CT accreditation phantom with goal to achieve CT dose reduction.

MATERIALS AND METHODS
CT accreditation phantom (American College of Radiology) was scanned on Dual Source CT scanner (Siemens FLASH®) at various x-ray tube-potentials (140, 120, 100, 80, 70 kVp) and at various tube current settings (with CAREDOSE, 200, 150, 100 and 50 eff mAs respectively). Each CT scan series was then reconstructed using conventional FBP and with SAFIRE reconstruction of levels 1-5. All images were evaluated for image noise, contrast to noise ratio (CNR), low contrast resolution, high contrast spatial resolution, CT number accuracy and uniformity.

RESULTS
Decreasing kVp from 120 to 100 kVp results in a significant increase in image noise and loss of CNR. Comparing CNR at Safire levels 1 through 5 with FBP resulted in significant decrease in noise and increase in CNR at both 120 and 100 kVp. When compared to radiation dose (reduction of 40% from 120 to 100 kVp), Safire level of 3 at 100 kVp yielded similar CNR and lower image noise. CT number accuracy is not affected by the iterative reconstruction compared with FBP method.

CONCLUSION
Iterative reconstruction appears to compensate for increase in image noise associated with low radiation dose at low tube potential while improving CNR. Safire level of 2 and 3 on 100 kVp exams yields similar image noise at 120 kVp reconstructed with FBP for a gain of nearly 40% dose reduction.

ICMP 2013

DAY 3, TRACK 2

QA MAMMOGRAPHY SESSION

Paper Number: 0236

DOSE REDUCTION FOR DIGITAL MAMMOGRAPHY BY MEANS OF GRID-LESS ACQUISITIONS AND SCATTER CORRECTION

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Recently Siemens introduced a software-based scatter correction for grid-less digital mammography acquisitions. The aim of this study was to calculate the dose reduction that can be achieved under the requirement of identical image quality compared to acquisitions with grid. Image quality was evaluated using the CDMAM phantom (Artinis, NL, serial number 1033), a contrast-detail phantom used in European breast screening programs. In total, 480 contrast detail phantom measurements were performed at various dose levels and PMMA thicknesses, with and without using the anti-scatter grid. Eight images were acquired for each imaging condition. Measurements were made on a Siemens Inspiration system (Erlangen, D). The images were analyzed using computer readout with the Erica2 software (qaelum NV, B) which implements the CDCOM automated scoring method for CDMAM. It was found that dose reduction can be achieved with grid-less acquisitions. Scatter correction didn't influence the detection rate of the software but an improvement of image homogeneity was observed. Dose reduction was calculated as the average of the achieved dose reductions for the threshold gold thicknesses at diameters 0.1mm, 0.25mm and 0.5mm. The highest dose reduction, 26%, was found for the 21mm breast equivalent thickness (i.e. 20mm PMMA). Dose reduction is also possible for higher thicknesses: for 32mm, 45mm, 60mm and 75mm breast equivalent thicknesses, the average dose reductions were 17%, 18%, 14% and 4% respectively. The results suggest that grid-less acquisitions with or without scatter correction can be used for reducing the dose while maintaining image quality, especially for thinner breasts.

Paper Number: 0281

CONTRAST-ENHANCED MAMMOGRAPHY USING A PIXELLATED SPECTROSCOPIC DETECTOR.

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Many techniques to improve the detection of tumours in the breast have been developed in the last few years. Standard dual-energy imaging is typically implemented with two narrow-band X-ray beams. This technique requires two separate acquisitions to obtain two images, below and above the absorption-edge of a given contrast agent. The main disadvantages of this technique are higher dose to patients due to double exposure and possible motion artefacts due to patient movement between exposures. This work proposes an approach using a polychromatic X-ray beam produced by a tungsten-anode X-ray source, to provide for better accessibility for the patients and a pixellated spectroscopic CdTe detector to remove these disadvantages.

A custom made 3-components phantom simulating breast structures, consisting of superimposed tubes of different diameters containing iodinated contrast agent, was imaged. Pairs of images, below and above the absorption-edge of iodine, were simultaneously acquired by integrating different energy bands of the transmitted spectrum, and combined using simple logarithmic subtraction and a more general dual energy algorithm allowing the extraction of an iodine-equivalent and a water-equivalent image. Results are presented in terms of contrast-to-noise ratio as a function of the width of the integration bands chosen and of delivered dose.

Results confirm the feasibility of performing low-dose dual-energy imaging using a standard X-ray source and a spectroscopic detector. Results proved the effectiveness of dual-energy imaging to enhance the contrast uptake areas, by removing the background. Dual-energy algorithm performs better than simple logarithmic subtraction in terms of contrast improvement and structural noise reduction.

Paper Number: 0285

MONTE CARLO MODELLING OF CONTRAST-ENHANCED DIGITAL MAMMOGRAPHY X-RAY SPECTRA

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The methodology for the calculation of mean glandular dose (MGD) for mammography in the UK is well established. The advent of full field digital mammography has enabled the recent development and initial distribution of contrast-enhanced digital mammography (CEDM) systems. No spectral correction factors are presently available to allow the estimation of MGD in CEDM, therefore the assessment of patient dose cannot be performed.

To produce the necessary factors, a Monte Carlo simulation of the CEDM procedure must be carried out. The simulation requires knowledge of the X-ray production and transmission steps of the imaging chain. The objective of this preliminary investigation is to obtain accurate beam spectra relevant to CEDM.

The X-ray system will be Monte Carlo modelled using the EGSnrc code. X-ray spectra will be constructed for conventional mammography (24-36 kVp) and CEDM (45-49 kVp) beam qualities. The former spectra will be used to validate the modelling method used against well-established existing models. The latter will be compared to data available in the literature which have been acquired through measurement or calculation.

Upon completion of this work, conclusions will be drawn based on the level of agreement between the spectra that we have produced and those found in the literature. Discrepancies will be investigated.

Paper Number: 0156

SLICE DEPTH AND RESOLUTION PHANTOM FOR DIGITAL BREAST TOMOSYNTHESIS

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INTRODUCTION

Digital Breast Tomosynthesis (DBT) is becoming widespread. This relatively recent modality has inherent artefacts resulting from current technology. These raise questions regarding the ability of such systems to achieve consistent resolution at all depths. Verification of depth measurement for depth localisation of objects within the image sets also needs to be addressed. The uncertainties associated with these measures require quantification.

AIM

To determine the vertical positioning of, and resolution within, reconstruction planes in DBT using a purpose built phantom.

METHODOLOGY

A prototype phantom consisting of dental wax and 200-250µm calcium specks (ground marble composed of CaCO3) was constructed. The error in the thickness measurement of the phantom was of the order of 0.05mm. The calcifications were arranged in different patterns at different depths which allowed identification of specific slices and evaluation of contrast in each slice. A LORAD Hologic Selenia Dimensions mammography unit was used for all tomosynthesis exposures. The images were displayed and analysed on Mammographic reporting screens.

RESULTS

The phantom design used was found to be appropriate. The maximum standard deviation obtained from the slice number and position in the slice is 0.8%. The tomosynthesis reconstruction slice depths were as stated on the unit within an uncertainty of +/-0.05mm. In some of these images artefacts were present, but these did not affect the ability to identify the specks.

CONCLUSION

The proposed phantom allowed successful evaluation of the positions of the image reconstruction planes. Use of smaller calcium specks will allow resolution threshold determination.

Paper Number: 0121

IMAGE QUALITY AND DOSE IN MAMMOGRAPHY IN PAKISTAN: RESULTS FROM IAEA PROJECTS RAS/9/065

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PURPOSE
The objective is to study mammography practice from an optimization point of view by assessing the impact of simple and immediately implementable corrective actions on image quality.

MATERIALS AND METHODS
This prospective multicentre study included 40 mammography units in 27clinics. More than 10,000 mammography images were evaluated using a three-level image quality scoring system. Following initial assessment, appropriate corrective actions were implemented and image quality was re-assessed in 24 units.

RESULTS
The fraction of images that were considered acceptable without any remark in the first phase (before the implementation of corrective actions) was 70% and 75% for cranio-caudal and medio-lateral oblique projections, respectively. The main causes for poor image quality before corrective actions were related to film processing, damaged or scratched image receptors, or film-screen combinations that are not spectrally matched, inappropriate radiographic techniques and lack of training. Average glandular dose to a standard breast was 1.5 mGy (mean and range 0.59–3.2 mGy).After optimisation the frequency of poor quality images decreased, but the relative contributions of the various causes remained similar. Image quality improvements following appropriate corrective actions were up to 50 percentage points in some facilities.

CONCLUSIONS
Poor image quality is a major source of unnecessary radiation dose to the breast. An increased awareness of good quality mammograms is of particular importance for Pakistan as we are moving towards introduction of population-based screening programmes. The study demonstrated how simple and low-cost measures can be a valuable tool in improving of image quality in mammography.

Paper Number: 0187

AUTOMATED QC MEASUREMENTS IN MAMMOGRAPHY

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Routine QC (Quality Control) of digital mammographic equipment is performed regularly by radiographers and physicists. The base-lines established by physicists at commissioning or after a system change are compared against tests performed daily, weekly and monthly by radiographers. Remedial values and tolerances are specified by the NHS Breast Screening Programme. The routine QC tests performed by radiographers can be time consuming and a measure of variability is introduced when fixing the size and location of regions of interest in the analysis. Automated software has the potential to reduce the variability inherent in human analysis. In addition, more complicated and comprehensive types of analysis that are not feasible in human analysis are possible.

To this end a system has been developed to perform automatic measurements on QC images. Seven mammography systems have been monitored since July 2012 with a further two systems connected in February 2013. The collection of images and analysis has been fully automated. At the time of submission, 1,855 images have been analysed. The analysis tools replicate the standard QC measurements at defined points as well as providing data on the variance and uniformity across the whole of the detector. By analysing change in local variance it was possible to identify subtle changes in detector performance that would otherwise go unnoticed using current routine QC analysis. These tools can be run as a plugin for ImageJ or as a component of a larger application. A web-application has been developed allowing the results to be available over the Internet.

ICMP 2013

DAY 3, TRACK 3

SFOV GAMMA CAMERAS FOR INTRAOPERATIVE IMAGING

Invited Speaker

AN INTRODUCTION TO SFOV GAMMA CAMERA SYSTEMS FOR INTRAOPERATIVE IMAGING

Alan Perkins

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Apart from a small number of mobile systems produced in the nineteen eighties and nineties, gamma cameras have traditionally been large bulky instruments restricted to operating in nuclear medicine departments. Recent advances in detector design have led to the introduction of new instruments with pixelated scintillators, position sensitive photomultipliers and solid-state detectors such as cadmium telluride (CdTe) and cadmium zinc telluride (CZT). These developments have led to the production of a new generation of low cost and portable small field of view (SFOV) gamma cameras capable of high resolution imaging and suitable for use at the patient bedside, intensive care unit or operating theatre.

These cameras commonly employ a compact detector head weighing about around 1 kg and typically have a useful field of view of around 5 cm (square or circular) and often incorporate additional mechanisms to provide positional information for localisation of sites of uptake in the patient during surgical exploration. The development of hybrid camera systems is particularly promising since this will provide surgeons with the superimposition of image information for localisation of activity within the open surgical area and will provide an image for documentary evidence of tissue localisation and excision.

This new generation of compact cameras can provide a useful role in imaging small organs such as the thyroid, parathyroid and lacrimal drainage from the eye. In addition they have the potential to replace hand held probes for pre-surgical and intra-operative lymphoscintigraphy for the detection of sentinel lymph nodes and for other surgical applications such as the excision of osteoid osteoma, bone lesions and other tumours.

Invited Speaker

DESIGN AND USE OF MOBILE GAMMA CAMERAS IN BREAST CANCER

Marie-Alix Duval[1,2], Alexandre Bricou[3], Yves Charon[1], Emmanuel Barranger[4]

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More and more mobile gamma cameras are being designed and used for pre-operative and intraoperative uses. Among all the applications radioguided breast cancer surgery is still the main clinical use of these cameras as much for sentinel lymph node biopsy as for non-palpable lesion excision (radioguided occult lesion localisation (ROLL) or sentinel node and occult lesion localisation (SNOLL)). At this point it is interesting to review which cameras have been evaluated on patients and what kind of conclusion has been drawn from these trials. We can sort these devices in two categories: the hand held ones and the cameras mounted on articulated arms. Whereas we can compare the cameras' different features such as type of detector, field of view, weight, sensitivity, spatial and energy resolutions, there is no possible comparison between the clinical trials mainly because the protocols are different. Whatever the procedure these cameras bring real time imaging into the operating theatre, and they appear to be very useful tools to second mono-pixel probes. They provide comfort and assistance to the surgeon to accurately localize sentinel lymph nodes and/or radio-labeled tumors, and to verify that all radioactive nodes have been excised.

Keywords: Breast cancer; sentinel lymph node biopsy, ROLL, SNOLL, hand-held camera; mobile gamma camera, radio-guided surgery; intra-operative; pre-operative gamma cameras

Invited Speaker

A HIGH RESOLUTION GAMMA-OPTICAL HYBRID CAMERA FOR MEDICAL IMAGING

John E. Lees

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There is now wide spread interest in the application of small field of view gamma cameras for clinical use in operating theatres, intensive care units and bedside imaging.

Clinical and surgical applications are driving the need for a new generation of compact gamma camera systems with a small field of view but superior resolution to the conventional large gamma cameras. When designing such a system it is important that it should have both high resolution and high sensitivity to ensure that clinical procedures may be undertaken away from the nuclear medicine department, using low amounts of administered radioactivity. Such systems should detect gamma photon energies throughout the full range of clinically useful diagnostic radionuclides, nominally within the photon range 50 - 250keV.

A new concept for a medical imaging system, the Hybrid Mini Gamma Camera (HMGC) will be presented. This new type of imager combines an optical and a gamma-ray camera in a co-aligned configuration that offers high spatial resolution multi-modality imaging for superimposition of a scintigraphic image on an optical image. This configuration provides visual identification of the sites of localisation of radioactivity that would be especially suited to medical imaging. An extension of the new concept using two hybrid cameras (The StereoScope) offers the potential for stereoscopic imaging with depth estimation for a gamma emitting source.

Invited Speaker

A PORTABLE GAMMA CAMERA FOR INTRAOPERATIVE REAL TIME IMAGING OF SENTINEL LYMPH NODES IN EARLY BREAST CANCER: IS THIS THE WAY FORWARD?

Mohammed R. Keshtgar[1], Debashis Ghosh[1], Nikolaos V. Michalopoulos[1], Casper Wickham[2], Norman R. Williams[3], Timothy Davidson[1]

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BACKGROUND
Access to nuclear medicine department for sentinel node imaging remains an issue in number of hospitals in the UK and many parts of the world. Sentinella® is a portable imaging camera used intra-operatively to produce real time visual localisation of sentinel lymph nodes. It also has an inbuilt gamma detection proben assist identification of SLN during surgery.

MATERIAL AND METHODS
Sentinella® was tested in a controlled laboratory environment at our centre and we report our experience on the first use of this technology from UK. Moreover, preoperative scintigrams of the axilla were obtained in 144 patients undergoing sentinel node biopsy using conventional gamma camera. Sentinella® scans were done intra-operatively to correlate with the pre-operative scintigram and to determine presence of any residual hot node after the axilla was deemed to be clear based on the silence of the hand held gamma probe.

RESULTS
Sentinella® detected significantly more nodes compared with CGC ($p<0.0001$). Sentinella® picked up extra nodes in 5/144 cases after the axilla was found silent using hand held gamma probe. In 2/144 cases, extra nodes detected by Sentinella® confirmed presence of tumour cells that led to a complete axillary clearance.

CONCLUSIONS
Sentinella® is a reliable for intra-operative localisation of radioactive nodes. It provides increased nodal visualisation rates compared to static scintigram imaging and proves to be an important tool for harvesting all hot sentinel nodes. This portable gamma camera can replace the use of conventional lymphoscintigrams saving time and money both for patients and the health system.

ICMP 2013

DAY 3, TRACK 3

BACK TO THE FUTURE FOR NUCLEAR MEDICINE AND PET

Invited Speaker

SOLID STATE SPECT CAMERAS: THEORY AND DESIGN

Professor Brian Hutton

Institute of Nuclear Medicine, UCL, London, UK and Centre for Medical Radiation Physics, University of Wollongong, NSW, Australia.

Traditionally SPECT systems were designed using scintillation detectors with photomultiplier tube readout, usually using conventional Anger cameras. Recently a number of 'solid state' cameras have been commercially released either based on solid state detectors (e.g. cadmium zinc telluride (CZT)) where gamma energy is directly converted to a readable electronic signal or using solid state readout technology (e.g. pin diodes (PD), silicon drift detectors (SDD) or silicon photomultipliers (SiPM)) together with conventional scintillation detectors. The new technologies offer potential for improved energy resolution (CZT), improved intrinsic resolution, compact design, high count-rate capability and magnetic compatibility well suited to use for multi-radionuclide studies, dynamic studies and use in hybrid systems (e.g. SPECT/MRI). Combined with the flexibility in adapting iterative reconstruction algorithms to match system geometry, this has facilitated introduction of novel organ-specific SPECT systems that includes adaptive SPECT options. Potential future designs can take advantage of improved intrinsic resolution in combination with collimators that minimize the projections, but achieve superior system sensitivity. The detectors are also well suited for integration with MRI and several groups are actively developing hybrid SPECT/MRI systems. The current status of solid state SPECT systems will e reviewed.

Invited Speaker

CERENKOV LUMINESCENCE FROM RADIONUCLIDES: A NEW TOOL FOR IMAGING AND THERAPY?

Simon R. Cherry, Ph.D.

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Beta decay of radionuclides can produce electrons or positrons that move through tissue faster than the speed of light in tissue. This leads to the emission of visible light due to constructive interference via the Cerenkov effect. A number of laboratories have shown that measurable Cerenkov radiation is produced in vivo following administration of □□□□-emitting radionuclides and that this light can be used for in vivo molecular imaging in small-animal subjects. This has led to the concept of Cerenkov luminescence imaging (CLI) that allows the spatial distribution of biomolecules labeled with □□□□-emitting radionuclides to be imaged in vivo using sensitive charge-coupled device (CCD) cameras. CLI allows many common radiotracers to be imaged on widely available in vivo optical imaging platforms, and more importantly, provides a pathway for directly imaging beta-emitting radionuclides that are being developed for therapeutic applications in cancer and that are not readily imaged by existing methods. This presentation will review the physics of Cerenkov radiation as it relates to in vivo molecular imaging, and present computational results that predict the light yield and spatial distribution for a range of biomedically-relevant radionuclides. In vivo studies in mouse models using beta-emitting radionuclides will be shown in order to illustrate possible applications of the technique. The possibility of using the emitted Cerenkov radiation for phototherapy also will be explored. Finally, the potential for clinical applications will be discussed, and the strengths and weaknesses of Cerenkov imaging will be defined.

Paper Number: 0158

RESPIRATORY GATED SPECT VQ LUNG IMAGING: IMPROVED VISUALIZATION OF DEFECTS SHOWN BY DYNAMIC PHANTOM STUDIES

Reem Darwesh[2], Evelyn Shin[3], Paul. S Morgan[3], Alan. C Perkins[1]

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PURPOSE
The EANM guidelines recommend SPECT V/Q for the diagnosis of pulmonary embolism. However, respiratory motion degrades image quality by increasing blur. To overcome this, we investigated respiratory-gated SPECT imaging, where temporal bins were motion-corrected to a reference phase and then summed.

METHODS
Wedges of different sizes were fixed in the lung cavities of an anthropomorphic lung phantom to simulate perfusion defects. The cavities were filled with 200 MBq Tc-99m. Gated (16-bin) and non-gated SPECT images were acquired with 3-dimensional motion introduced at 10 and 20 cycles per minute using a purpose-built moving platform and motion tracked with the ANZAI respiratory gating system. SPECT data were reconstructed using ordered-subset expectation maximisation algorithms (HOSEM) and corrected for rigid motion using motion correction software. Contrast and contrast-to-noise ratios (CNR) were measured for wedge defects to quantify any improvement between motion-corrected and uncorrected images. Visualisation of defects in the reconstructed images was assessed by seven observers and analysed using free- response receiver operating characteristic (AFROC) analysis.

RESULTS
Assessment of gated and non-gated SPECT images demonstrated that motion adversely affected the detectability of the wedge defects. In the phantom simulation, image quality, defect definition, observer confidence, contrast and CNR increased after motion correction. The improvement of detectability was found to be significant using AFROC analysis ($p=0.0002$).

CONCLUSION
Respiratory-gated motion-corrected SPECT images enhanced the visualisation of defects compared with non-gated, moving phantom data. This approach may be particularly valuable for SPECT V/Q imaging and may improve the diagnosis of pulmonary embolism.

Paper Number: 0234

MANUFACTURE AND DEVELOPMENT OF PATIENT SPECIFIC PHANTOMS USING RAPID PROTOTYPING TECHNOLOGY

Jonathan Gear[1], Clive Long[1], Dominic Rushforth[1], Craig Cummings[2], Glenn Flux[1]

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Anatomical phantoms are used in molecular imaging for quantitative assessment of image quality. However, these phantoms are expensive and do not necessarily represent the patient or cohort of interest. The present study investigates the feasibility of using rapid-prototyping-technology to produce cost-effective liquid fillable phantoms directly from patient CT data.

Anatomical data were obtained from the CT component of a half body PET/CT scan. Liver, spleen and kidney volumes were segmented and converted into shelled structures, (wall thickness 2mm) and saved as STL files. Phantoms were printed using an Objet EDEN500V. The printer uses stereolithography technology combined with ink jet printing. 16 micron layers of liquid photopolymer are printed over each other and cured using an ultraviolet laser. Final print material is a clear solid plastic, with reasonable tensile strength, low water absorption and density similar to water (1.09g/cm3).

All organs were printed in two halves. The liver took approximately 36 hours to complete, smaller organs were printed simultaneously and took 7 hours. Total material cost was approximately €700, considerably less than the purchase price of commercial alternatives. Initial scans of the phantoms have been performed with F-18 PET/CT. Hounsfield units of the phantom material are similar to acrylic and organ shape showed good correspondence with anatomical references.

We have demonstrated that rapid prototyping technology can be easily used to produce cost effective phantoms for use with molecular imaging. These phantoms can be used to provide validation of PET/SPECT and dosimetry applications for both external and molecular radiotherapy.

ICMP 2013

DAY 3, TRACK 3

ADVANCES IN PET

Invited Speaker

ADVANCES IN PET MATHEMATICAL MODELLING - FROM TRACERS TO TRIALS

Roger N. Gunn

Imperial College London & Imanova Ltd, London, UK

Positron emission tomography (PET) is an important imaging tool for the measurement of human pathophysiology and for the reduction of risk in drug development. Mathematical modelling is a critical enabler for PET imaging and impacts on the technology all the way from probe development through to trial design and analysis. This presentation will review some of the latest advances in these areas with a focus on applications in neuroscience drug development including;

- Biomathematical approaches that use in silico and in vitro data to screen compound libraries and reduce attrition in the discovery and development of novel imaging probes

- Mathematical models and analysis methods for the quantifcation of outcome measures free from confounds from individual dynamic scan data

- Mathematical models for the quantification of the relationship between plasma drug concentrations and drug-target engagement even in the presence of inceased target residence times

- Optimal adaptive designs of PET clinical trials that maximise the information derived whilst minimising the number of subjects required

Paper Number: 0196

VALIDATING 18F-FDG PET AUTOMATED SEGMENTATION METHODS FOR CLINICAL USE IN H&N.

Beatrice Berthon[1], Robin Holmes[2], Christopher Marshall[1], Mererid Evans[3], Andrew Edwards[4], Emiliano Spezi[4]

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AIM

Recently published data suggest that there is currently a need for solid cross-comparison of automatic methods for the delineation of teh Gross Tumour Volume (GTV) on Positron Emission Tomography (PET) images. This study aimed to quantitatively validate several automatic methods on PET data relevant to the H&N anatomy, using non-spherical phantom inserts and a sub-resolution printed phantom.

MATERIALS AND METHODS

Seventeen non-spherical geometrical volumes, including tubes, ellipsoids, toroids, pear- and drop-shaped objects, were scanned in a custom plastic phantom at a Tumour-to-Background ratio of five. Eight grey level patterns modeling background and tumour uptake in the H&N, printed with 18F-FDG and ink on a HP deskjet 990cxi, were assembled between 2mm-thick Perspex sheet. Both 3D phantoms were scanned on a GE Discovery 690 PET/CT scanner. The delineation performance of nine custom segmentation methods (including gradient-based, thresholding, region-growing and clustering schemes) was quantified using Volumetric Error (VE), Dice Similarity Index (DSI) and percentage error in recovered shape dimensions.

RESUTS AND CONCLUSION

All automatic methods except Fuzzy C-means clustering performed significantly better ($p<0.01$) than fixed thresholding for non-spherical objects. Adaptive Thresholding (AT) and Region-Growing (RG) performed best for both non-spherical objects (average DSI of 0.88, 0.86 and VE of 20%, 33% respectively) and printed patterns (DSI of 0.76 for both, VE of 8% and 4% respectively). Preliminary results also highlighted the superior performance of Gaussian Mixture Clustering (GCM) for heterogeneous lesions (0.74 DSI and 8% VE). AT, RG and GCM are proposed as promising methods for GTV delineation in H&N.

Paper Number: 0331

THE EFFECT OF THE GE SHARPIR PET RECONSTRUCTION ON CONTRAST CONVERGENCE AND MEASURED SUV VALUES IN THE NEMA IMAGE QUALITY PHANTOM AND PATIENTS

Katharine Kenny, Daniel McGowan

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A study has been undertaken to investigate the benefit of using the GE Resolution Recovery (SharpIR) algorithm and its effect on PET image quality for a phantom and patients.

A NEMA Image Quality phantom was scanned on a GE Discovery 690 PET/CT scanner. The scan data was processed using a time-of-flight (TOF) iterative reconstruction with and without SharpIR, with one to five iterations, 24 and 32 subsets and 2mm, 4mm and 6.4mm Gaussian filters. Image quality was assessed using contrast recovery curves, and the optimum clinical processing parameters were determined and used on a variety of patients to investigate the improvement in imaging small lesions.

SharpIR gave a significant increase in contrast recovery for the phantom's small spheres (of the order of 10mm), and an increase in contrast of up to 40% (17% absolute increase) compared to the standard TOF reconstruciton, but an additional iteration was required to achieve contrast convergence. For the large spheres there was no significant increase in contrast recovery. For patient studies reconstructed using SharpIR a significant increase in maximum standardised uptake value (SUVmax) of up to 78% was found for small lesions. For larger lesions the increase in SUVmax was less significant.

We conclude that the SharpIR algorithm gives a significant benefit for small lesions, requiring an additional iteration in the reconstruction. For clinical studies this leads to an increase in SUVmax values. Care must therefore be taken when comparing SUVmax values for longitudinal studies. Recommended reconstruction parameters for clinical practice will be presented.

Paper Number: 0367

IMPROVING QUANTIFICATION OF PULMONARY NODULES IN NON-SMALL CELL LUNG CANCER (NSCLC) PATIENTS WITH RESPIRATORY GATED PET-CT

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Radiological Sciences Unit, Hammersmith Hospital, Imperial College Hospital NHS Trust, London, UK

AIM

To evaluate respiratory correlated and gated PET-CT datasets in a moving phantom and NSCLC patients.

METHODS

The NEMA IEC Body Phantom was filled with 18F-FDG (4:1 contrast) and placed on a linear sliding table. The programmed platform moved sinusoidally specifically (amplitude 2cm, frequency 0.2Hz) to simulate the typical respiratory volume curve. The Anzai Respiratory Gating device was used to measure motion. A static PET-CT dataset was collected, followed by a moving PET-CT dataset in list mode. The PET-CT datasets were correlated with the Anzai signal to obtain gated datasets. Each individual gate was registered to the gate at expiration, and the co-registered gates were summed to produce a motion corrected PET frame. The static, moving, gated and motion corrected datasets were evaluated using threshold-based SUVmax and apparent volume measurements.

RESULTS

The moving 10mm sphere was difficult to visualise. Preliminary results indicate variation between datasets for spheres of diameter 13, 17, 22, 28 and 37mm. The percentage difference in SUVmax between the moving and static data was found to be 23%, 21%, 16%, 6% and 1% respectively. Gating was seen to decrease the percentage variation in SUVmax, and increase the apparent volume of spheres giving variations closer to the static frame. Further phantom studies will be carried out.

CONCLUSIONS

Performing gating and motion correction on PET-CT datasets can help improve characterization of pulmonary nodules in NSCLC patients. Future work will involve using gated CT for motion correction of data. The results from phantom and some patient studies will be presented.

ICMP 2013

DAY 3, TRACK 3

NON INVASIVE DIAGNOSTICS AND OPTICAL IMAGING

Invited Speaker

THE DIAGNOSTICS DEVELOPMENT UNIT: BLENDING MEDICINE, PHYSICS AND CHEMISTRY TO ACHIEVE NON-INVASIVE DIAGNOSTICS

Prof. Mark Sims[1], Prof. Tim Coats[2]

[1] Space Research Centre, [2] Department of Physics and Astronomy and Cardio-Vascular Sciences University of Leicester

The Diagnostics Development Unit has been set up at the Leicester Royal Infirmary. This University of Leicester project is aimed at using modern technology to see, feel and smell the patient to detect appropriate physiological biomarkers and ultimately develop a physiological phenotype for non-invasive diagnosis of disease. The DDU is set-up in the Accident and Emergency (A&E) Department and aims to complement invasive testing using three measurement modalities, namely: Imaging (Thermal IR, Visual and Near-IR spectral imaging); Breath and Gas Analysis (detecting volatile organic compounds in breath or from head space gas from body secretions and waste products); and Cardio-vascular monitoring (using a suite of monitors). These measurements enable everything from the visual appearance i.e. the patients pallor, temperature of the patient, their breath and functioning of their cardio-vascular system to be measured in quick succession. Discussion with clinicians produced over 40 possible disease states that could be investigated. Currently a study of 400 patients consisting of 20 patients of the top 20 presenting complaints e.g. chest pain, breathlessness to A&E is underway and a small study of fever and sepsis has been completed. Other clinical studies are being planned. Although the DDU equipment is presently used in A&E, it and derived bespoke devices will it is hoped find application in primary, secondary care, the next generation ambulances and perhaps ultimately in the home or local chemist. This talk describes the clinical need, the DDU, the measurement technologies and results so far, along with the clinical implications of the DDU.

Invited Speaker

TRANSLATING FLUORESCENCE MOLECULAR IMAGING

E.M. Sevick-Muraca, Ph.D.

Professor of Molecular Medicine and Kinder Distinguished Chair of Cardiovascular Research, The Center for Molecular Imaging, The Brown Foundation Institute of Molecular Medicine, The University of Texas Health Science Center, Houston, Texas USA.

Fluorescence molecular imaging differs from conventional nuclear techniques in that it requires tissue-penetrating radiation to activate photon emission, involves considerably lower photon energies, and results in potentially higher photon count rates. In this presentation, the device and imaging agent requirements for clinical translation are first summarized before the technology of near-infrared fluorescence (NIRF) lymphatic imaging, employing the trace administration of indocyanine green (ICG) for diagnosing human disease and for discovery research are described. Specifically, Phase I-II clinical studies of NIRFL lymphatic imaging in normal control subjects as well as in subjects with lympho-vascular abnormalities are presented. These human studies were originally designed to qualify the use of a military grade intensified camera system for detection of trace doses of future "first-in-humans" imaging agents and to define instrument performance for targeted NIRF imaging. With successful device performance demonstrated in the clinic, preclinical studies of dual labeled NIRF/PET mAb-based imaging agents targeting epithelial cell adhesion molecule (EpCAM) were conducted to mimic intraoperative imaging and found to be comparable with "gold-standard" uPET non-invasive studies. These studies may suggest the clinical of dual labeled NIRF/PET imaging agents for whole-body, pre-surgical planning, and corresponding intraoperative guidance.

Paper Number: 0314

COMPARISON OF HEART RATE VARIABILITY DATA DERIVED FROM ELECTROCARDIOGRAPHY AND PHOTOPLETHYSMOGRAPHY AND COMPARISON OF PULSE TRANSIT TIME WITH BEAT TO BEAT BLOOD PRESSURE MEASUREMENT

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Photoplethysmography (PPG) is an optical technique measuring peripheral blood volume changes and has been proposed as an alternative to ECG in measuring heart rate variability. The pulse transit time delay (PTT) between the ECG R-wave and the peak of the PPG pulse in the periphery has also been suggested as a surrogate measure of blood pressure.

ECG and PPG derived heart rate variability data were compared for 35 normal, healthy volunteers for whom full ECG and PPG data streams were obtained for 2 minutes of metronome guided deep breathing at 6 breaths per minute free of artefact. The rolling correlation coefficient technique was used to accurately time pulses in both signals. PTT was calculated for each dataset.

Only very small differences were found between ECG derived and PPG derived heart rate variation parameters (e.g. SD heart rate 5.30+/-2.61 bpm for ECG, 5.38+/-2.60 bpm for PPG). However, unlike previous published work, these differences were found to be statistically significant ($p<0.0001$ for SD heart rate). Those studies identified as abnormal using ECG were also identified as abnormal using PPG. Overall correlation between beat to beat PTT and beat to beat blood pressure measured with Portapres was poor, but an inverse correlation between the blood pressure and PTT was clear in some studies.

PPG is reliable as an alternative measure for heart rate variability studies, but absolute values may differ slightly. Although PTT does not correlate well with blood pressure during metronome guided breathing, a clear relationship was observed in some studies.

ICMP 2013

DAY 3, TRACK 4

RADIOTHERAPY PROFFERED PAPERS

Paper Number: 0316

REPORTING CORRECTED SMALL FIELD RELATIVE OUTPUTS: A METHODOLOGICAL APPROACH

G. Cranmer-Sargison[1], P.H. Charles[2], J.V. Trapp[2], D.I. Thwaites[3]

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The goal of this work was to develop a method for reporting small field relative output and to assess the application of published correction factors across a population of linear accelerators. Measurements were made at 6 MV on five Varian iX linacs using two different PTW T60017 unshielded diodes. During each of three measurement sessions five central axis output readings and five profile measurements were made for jaw collimated square field sizes of side down to 0.5 cm. The standard experimental uncertainty was calculated for both output and field width, defined as the FWHM at 50% in A (in-plane) and B (x-plane). An effective field size defined as (A x B)1/2 was calculated using the measured field widths. To account for the diode over-response in small fields the effective field size was used to linearly interpolate between published MC calculated correction factors. When the relative output data was plotted as a function of the nominal field size there appeared to be a significant difference in the relative output across the linac population. However, when the same output data was plotted as a function of effective field size there was no discernible difference in relative output across all linacs. The proposed methodology removes much of the ambiguity in reporting and interpreting small field dosimetric quantities and facilitates a clear dosimetric comparison across a population of linacs. It has also been shown that the effective field size can be corrected using linear interpolation between published correction factors.

Paper Number: 0096

AN EXPERIMENTAL AND MONTE-CARLO STUDY OF IN-VIVO DOSIMETRY IN SMALL RADIOTHERAPY FIELDS USING IN-VIVO DIODES AND TLD

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INTRODUCTION

In-vivo dosimetry is recommended for treatment verification. Although modern techniques use small fields increasingly, in-vivo measurements are often not performed for small fields due to difficulties in measuring the dose accurately. OBJECTIVE: To investigate the suitability of various dosimeters for performing in-vivo measurements in small 6 MV photon fields by measurement as well as Monte Carlo simulation using our previously validated and detailed MCNP4C model of an Elekta accelerator's head.

MATERIALS AND METHODS

Diode detectors (EDD-5, EDP-10 and EFD) and 3.1×3.1×0.9 mm3 LiF TLDs were used for dosimetric measurements in a water tank and a custom-made PMMA phantom. Dose perturbation effects of the in-vivo detectors were investigated at different depths and in field sizes down to 1×1 cm2.

RESULTS

In fields larger than 2×2 cm2, EDP-10, EDD-5 and TLD produced 10%-11%, 1%-2%, and ~1% dose perturbation, respectively, and differences in the results of EDD-5, EDP-10 and TLD from the Monte-Carlo gold-standard were <2%. For the 1×1 cm2 field, however, the differences from the gold-standard were all greater than 2% due to the influence of detector size as well as any misalignment and set-up uncertainties.

CONCLUSIONS

Unlike TLD, a better than 2% dosimetric accuracy was not achieved by these in-vivo detectors for field sizes smaller than 2×2 cm2. Routine patient in-vivo dosimetry is feasible with the EDD-5 diode and TLD for fields as small as 2×2 cm2 without exceeding the 5% tolerance level for overall uncertainty. The EDP-10 diode produces a higher perturbation making it much less suitable for this purpose.

Paper Number: 0191

IODINE-125 SEED PROSTATE BRACHYTHERAPY: SEED PREDICTION AND CLASS SOLUTIONS?

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PURPOSE
A study was carried out to investigate how class solutions for I-125 seed prostate brachytherapy might be programmatically produced by analysing manually created treatment plans at Leeds Teaching Hospitals. A class solution can shorten the length of treatment because the time needed to plan individual patients can be reduced and needle/seed preparation can be carried before treatment.

METHOD
Treatment plans for 803 patients treated between years 2000-2012 were collected. The needle position and seed number of each plan were correlated with the prostate dimensions (volume, height, width, and lengths). An in-house program was written to filter the plans by prostate volume. Needle positions that fell outside of the prostate dimensions were removed from the filtered plans. Using a nomogram, the number of seeds to implant was calculated and compared with the number of seeds predicted by the program. A finalised predicted plan was achieved by keeping needles whose frequency probability was above a user-adjustable threshold value.

RESULT
The predicted plans were found to be ~80% accurate in predicting the needle/seed loading for a given prostate size. With ~30% of needles being loaded in the current practice, this method could significantly save time in needle loading before treatment.

CONCLUSION
The number of needles and seeds to load can be predicted when analysing manually created treatment plans for a large number of patients. Using the patient data in conjunction with a nomogram to calculate the number of seeds to implant, the number of needles to load can be predicted prior to planning.

Paper Number: **0074**

INFLUENCE OF PULSE LENGTH ON COLLECTION EFFICIENCY OF IONIZATION CHAMBERS IRRADIATED WITH PULSED BEAMS

Leonhard Karsch, Malte Gotz, Jörg Pawelke

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In ionization chambers not all released charge is collected due to recombination of charge carriers. A physical description of the correction factor has been established for pulsed beams for many decades. However, it is only accurate if the pulse length is short compared to the collection time of the ionization chamber. In this contribution a new, more generalized description of the saturation correction (i.e. for arbitrary pulse lengths) is presented.

Experiments have been performed using a Roos ionization chamber (TM34001, PTW Freiburg, Germany) because this model is a planparallel chamber often used in clinics. The pulse length dependence was investigated at the superconducting electron linear accelerator ELBE. For the new theoretical description a system of partial differential equations is solved iteratively. The free parameters were adjusted for best agreement with the experiment.

The experiment shows, that the established description of saturation correction is only valid for pulses shorter than 10 µs. Furthermore, our new theoretical description allows the determination of saturation correction in a wide range, e.g., for beam time structures which are experimentally difficult to realize and for longer pulse durations. Hereby the calculation results in a better understanding of the recombination process by giving insight into the dynamics of charge carrier distributions. In this way we can show that the established theoretical formalism is also valid at longer pulses, if the previoulsy used fixed parameters are reintroduced as pulse length dependent. For the Roos chamber the dependence of these parameters is demonstrated.

Paper Number: 0117

A SINGLE PLAN SOLUTION TO CHEST WALL RADIOTHERAPY WITH BOLUS?

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INTRODUCTION

Radiotherapy treatments of post-mastectomy chest walls are complex, with the requirement to treat close to skin necessitating bolus use. Commonly used 5mm and 10mm thick boluses develop full skin dose, requiring their removal for the latter half of the treatment and requiring two treatment plans to be generated: doubling the planning workload. Can a thinner bolus be used for all treatments, therefore requiring only one plan?

METHOD

We investigate the doses received using (A) half time 10mm thick Vaseline bolus - current situation; (B) brass mesh (Whiting and Davis) and (C) 3mm SuperFlab(Mick-radio Nuclear Instruments): for both 6MV and 15MV. Dosimetric measurements in solid water and an anthropomorphic phantom using Ionisation chambers and TLDs study the effect of the different bolus regimes on the photon depth dose curves (DDC) and skin surface doses.

RESULTS

The current 10mm thick Vaseline bolus on and off measured skin doses are compared to the brass mesh and 3mm SuperFlab. The brass mesh has the least effect on the DDC, with changes <0.7% for depths >dmax. Also, Brass mesh gives superior conformity to skin surfaces. Measurements on the anthropomorphic phantom demonstrate an increased skin dose compared to that achieved with our current treatment protocol.

CONCLUSIONS

Brass mesh has the least effect on the DDC whilst sufficiently increasing surface dose. It can be removed at any treatment fraction, based on a clinical decision, without the need for generating a new plan. Treating with one plan significantly reduces planning times.

Paper Number: 0307

ASSESSMENT OF GAMMA KNIFE SMALL FIELD OUTPUT FACTORS: A MULTI-DETECTOR APPROACH

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The scope of this work is to obtain a dataset of "reference" output factor (OF) results for the small fields of a Gamma Knife PERFEXION radiosurgery unit, and use it to determine the k (fclin, fmsr, Qclin, Qmsr) correction factors for detectors commonly used for OF measurements.

All measurements were conducted on a spherical (16cm diameter), Solid Water® phantom provided by ELEKTA. "Reference" OF results were obtained employing TLD-100 microcubes (1x1x1 mm3), EBT-2 Gafchromic films and cylindrical alanine pellets (5mm diameter, 2.5mm length); all sharing the favorable characteristic of minimal field perturbation. For each dosimetric system, a fine methodology was scheduled and adopted to suppress experimental uncertainties to minimum. Alanine results were corrected for volume averaging effects using GammaPlan TPS relative dose calculations. The k(fclin,fmsr,Qclin,Qmsr) correction factors for a shielded and two unshielded diodes, as well as for a PinPoint microchamber were then determined through comparison of corresponding measurements against "reference" OF data.

The mean measured alanine, TLD and EBT-2 OF results for the 4-mm beam were found in close agreement, within 0.5%. The corresponding experimental uncertainties were estimated equal to 0.74%, 2.01% and 4.00%, respectively. An error-weighted mean OF4mm value of 0.814±0.007 was calculated. Similar "reference" OF results were obtained for the 8-mm beam, yielding an OF8mm equal to 0.899±0.006.

Regarding k(fclin,fmsr,Qclin,Qmsr) factors, results suggest that diode detectors overestimate both OF4mm and OF8mm, whilst microchamber significantly underestimates them. For both dosimeters, deviations are greater for the 4-mm beam, while diode-overestimation is more pronounced for the shielded diode.

ICMP 2013

DAY 3, TRACK 4

DIAGNOSTIC INTERVENTIONAL CARDIOLOGY AND RADIOLOGY: DOSES AND EFFECTS

Invited Speaker

RADIOBIOLOGICAL ASPECTS OF INTERVENTIONAL CARDIOLOGY

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There is concern about interventional cardiology procedures where sometimes clinically significant radiation doses are delivered to the heart and neighbouring tissues. In past reports, fluoroscopy procedures have in some cases delivered over 10 Gy to overlying skin, producing severe early and late skin reactions. Heart doses are much smaller, but can be approaching the threshold dose of 0.5 Gy suggested by ICRP for induced circulatory disease. This is important especially in children who are generally more sensitive than adults. Latency periods for many radiation-induced heart conditions are generally more than 15 years, and the incidence continues throughout life, hence again the importance for children. The mechanisms of radiation induced heart disease appear to be different after acute high doses and low doses. In experimental systems, high doses produce the latency, dose-response, dose fractionation and dose-rate effects expected of late tissue reactions. However the responses to low acute and repeated doses are not readily predictable from the responses to high doses, and this is difficult to study in experimental systems because of the long latency relevant to humans. New in vivo systems are now being used where there is predisposition to radiation-induced heart disease within shorter periods and after lower doses, and these will be described.

Paper Number: 0259

CARDIAC DOSES FROM PAEDIATRIC INTERVENTIONAL CARDIOLOGY

David Keiller, Colin Martin, Anne McCurrach

Greater Glasgow Health Board, Scotland, UK

ICRP publication 120 gives advice on radiation protection in cardiology, and suggests that exposure of the heart to radiation above a threshold dose of 500mGy may lead to increased risk of cardiovascular disease. Children, in particular young infants, often undergo multiple diagnostic and interventional procedures to correct heart conditions. A study has therefore been performed to assess whether doses to the heart approached the level at which there may be a risk of cardiac effects. Kerma-area product data on fluoroscopically guided interventional cardiology procedures performed at the Royal Hospital for Sick Children (Yorkhill) in Glasgow over a 9 month period were obtained. These data were used in simulations using PCXMC dose calculation software to determine the cardiac equivalent doses arising from common procedures. Cardiac doses were calculated for typical procedures, and for the highest dose cases (determined from incident kerma-area product). Cumulative radiation doses received by those patients undergoing repeat procedures were also calculated. During the initial period the highest cardiac dose observed from one procedure was 330mGy and the highest cumulative dose from multiple procedures over the 9 month period was 165mGy. The radiation doses received by the heart during the initial phase of the study were found to be consistently below the suggested 500mGy threshold. The study is being extended to 15 months and results for this will be reported at the meeting. Results suggest that any increased risk of heart disease in later life among children undergoing heart investigations is likely to be small.

Paper Number: 0368

EVALUATION OF DOSES TO PATIENTS IN INTERVENTIONAL CARDIOLOGYANNA BENINI FRANTS PEDERSEN ERIK JOERGENSEN

Frants Pedersen, Erik Jorgensen, Anna Benini

University Hospital, Copenhagen, Denmark

There is concern about the fact that radiation doses delivered to patients in interventional cardiology might be too high and there is the possibility to reduce them keeping the same quality of intervention. The aim of this study is to evaluate patients' doses in a very large number of interventions, in order to increase awareness and discuss the possibilities to reduce them.

Method: The Catheterisation Laboratory (Cath Lab) of the Heart Centre at the University Hospital, Rigshospitalet, in Copenhagen, is equipped with 8 angiography units, of recent Philips and Siemens models. Each angiography unit has a dose area product (DAP) meter.

Results: Consecutive data of more than 90.000 diagnostic coronary angiography procedures, of more than 30.000 consecutive percutaneous coronary interventions (PCI) procedures, and about 1000 congenital heart disease procedures have been collected, and stored in a clinical data-base including the fluoroscopy time (FT) and the dose area product value (DAP). The registration started in 1998.

The evaluation of DAP is done dividing the data from the beginning of the registration in 1998 to 2008 and from 2008 to today. This to show that there is a considerable reduction of doses in the second period due to equipment implementation and radiation protection.

Conclusions: In general, doses to patients during cardiological procedures seem relatively low. However, less than 5% of patients receive relatively high doses. Patient BMI, procedure complexity and operator are important to doses. These variations should be taken into consideration in the effort to reduce doses in interventional cardiology.

Paper Number: **0032**

A PRACTICAL MODEL FOR SKIN DOSE ESTIMATION IN INTERVENTIONAL CARDIOLOGY

Lucy Mather, Matthew Dixon

Plymouth Hospitals NHS Trust, Plymouth, Devon, UK

A practical method for skin dose estimation for interventional cardiology patients has been developed to inform pre-procedure planning and post-procedure patient management. Entrance surface doses for certain interventional radiographic can exceed thresholds for deterministic skin injury, requiring documentation within the patient notes. The primary objective was to reduce uncertainty associated with current methods, particularly surrounding field overlap. This was achieved by considering rectangular field geometry incident on a spherical patient model in a polar coordinate system. The angular size of each field was quantified at the maximum radius of the patient sphere, i.e. the skin surface. Computer assisted design software enabled the modelling of a sufficient dataset that was subsequently validated with radiochromic film. Modelled overlap was found to agree with overlap measured using film to within 2.2o ±2.0o, showing that the overall error associated with the model was less than 1%. Mathematical comparison against exposure data extracted from procedural DICOM files was used to generate a graphical skin dose map, demonstrating the dose distribution over a sphere centred at the Interventional Reference Point.

Paper Number: 0312

OCCUPATIONAL EYE LENS DOSES IN INTERVENTIONAL CARDIOLOGY

Una O'Connor, Anita Dowling, Aoife Gallagher, Geraldine O'Reilly

St. James's Hospital, Dublin, Ireland

MOTIVATION

Monitoring of occupational eye doses is a current area of concern in radiation protection. In 2011, the ICRP recommended a substantial reduction in the equivalent dose limit for the lens of the eye, in line with a revised threshold of absorbed dose for radiation-induced cataracts. It is well established that staff doses in Interventional Cardiology (IC) can be significant, however there is a lack of published data on eye lens doses in terms of the quantity Hp(3).

METHODOLOGY

Occupational lens doses to staff in IC were measured over a 3-month period. Eye dosimeters calibrated to measure Hp(3) were used (EYE-D, Radcard, Poland). Five interventional cardiologists (from two hospitals) and one cardiology nurse were assessed. In general, eye dosimeters were positioned above lead glasses to obtain a worst-case measurement. One cardiologist wore an eye dosimeter both over and under the lead glasses to estimate the protection factor. Staff workload and patient Kerma-Area-Product (KAP) was recorded to allow further analysis.

RESULTS & CONCLUSION

Annual eye lens doses (Hp(3)) to IC staff in an Irish hospital setting have been measured and assessed in the context of the recommended ICRP lens limit of 20mSv per annum. A factor for eye dose per procedure and per unit KAP has also been estimated for Cardiology staff. Conclusions and recommendations for eye dose monitoring will be presented.

ICMP 2013

DAY 3, TRACK 4

PHYSIOLOGICAL MEASUREMENT

Invited Speaker

WEARABLE SENSORS AND THEIR APPLICATION IN HEALTHCARE

Prof. Dr. med. Dr.-Ing. Michael Marschollek

Acting director at Hannover Medical School

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Medicine and computer science are both rapidly changing domains. IT solutions already are deeply integrated into healthcare and facilitate significant advances in diagnostics and therapy. Considering our ageing population and the rising need of care, technology may also help to support caregivers and patients to maintain their independence and self-determination. Health-enabling technologies in general, and wearable sensors in particular, provide a means to measure objective long-term data about a person's state of health outside current healthcare institutions. Thus, they contribute to gather information which is relevant both for the person as well as for healthcare professionals.

Following a brief review of relevant epidemiologic indicators with regard to ageing populations, target research areas for the application of wearable sensors will be identified along with a set of general services. The state-of-the-art in these areas will be presented by means of exemplary projects. Furthermore, issues of sensor acceptance will be addressed critically with reference to recent survey results. Finally, challenges with regard to the integration of new sensor-based data in current application systems in health care will be addressed, leading towards sensor-enhanced health information systems.

Invited Speaker

WEARABLE SENSORS: A SMART SOLUTION FOR THE MONITORING OF VITAL SIGNS IN DAILY LIFE

Marco Di Rienzo

Centre for Innovation and Technology Transfer, Milan, Italy

Smart devices based on wearable sensors are more and more frequently employed to assess vital signs out of the laboratory setting in clinics, sport, occupational safety and wellness areas. An interesting technological advancement in this field has been recently represented by the availability of the so-called smart garments, namely, pieces of clothing embedding both sensors and wirings. Advantages of these systems include the ease of use, comfort and unobtrusiveness during activity. Indeed, they do not require any sensor positioning nor cable connection because everything is already integrated into the garment and this facilitates their applicability for the remote monitoring of elderly people at home, and performance monitoring in healthy subjects during work and sport activities or while exposed to extreme physical or environmental conditions.

In 2005 we developed our own prototype of smart garment, named MagIC, for the assessment of ECG, respiratory frequency and movement in daily life. This device is composed of a vest with embedded textile sensors and a portable electronic board. Over the years the system has been used to monitor more than 200 subjects, including cardiac patients during rehabilitation programs and healthy subjects in a variety of extreme environmental conditions including high altitude (on Mount Everest) and gravitational stress (during parabolic flights). In this presentation, the evolution of the MagIC project will be illustrated, starting from the initial design of the vest till the latest applications and enhancements which now allow the beat-by beat monitoring of cardiac mechanics in ambulant subjects.

CV - Marco Di Rienzo received his MSc degree in Electronic Engineering from the Politecnico of Milan, Italy in 1980. From 1980 he has been a career researcher at the Centro di Bioingegneria (now renamed Polo Tecnologico) of Fondazione Don Gnocchi. He is currently research coordinator of both the Laboratory of Cardiovascular Research and the Laboratory of Wearable Sensors and Telemedicine. He is also Adjunct Professor in the Faculty of Medicine at the University of Milan.

His main research interests are in signal processing, modelling of the cardiovascular control, physiology in space, domotics and development of textile-based wearable systems for biosignal monitoring, seismocardiography. He has published over 120 papers in peer-reviewed journals, is co-inventor on three patents related to biosignal detection, textile sensors and smart garments, and serves as a referee in several international journals. He is currently member of the IEEE EMB Society and the IEEE EMB Wearable Biomedical Sensors and Systems Technical Committee, the American Society of Physiology, the European Society of Cardiology (Working Group on e-cardiology), the European Society of Hypertension (Working Group on blood pressure and heart rate variability, member of the steering committee), the European Study Group on Cardiovascular Oscillations (member of the steering committee).

Paper Number: 0297

COMPARISON OF CRT AND LCD MONITORS AS VISUAL STIMULATORS FOR MULTIFOCAL VISUAL EVOKED POTENTIAL TESTING.

Maryke Fox[2], David Keating[3], Colin Barber[2], Alan Perkins[1]

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CRT monitors have long been used as stimulators for visual evoked potential (VEP) recordings but are no longer produced following the advent of cheap LCD monitors. LCD monitors operate in a fundamentally different way so it is essential that VEP responses from both types of monitor are compared to ensure equivalence.

Previous work has compared pattern reversal VEPs between LCD and CRT monitors but no study has compared multifocal VEP (mfVEP) responses.

This study was approved by the University of Nottingham Ethics Committee.

A commercially available LCD and a CRT monitor were luminance- and contrast-matched. They were assessed for luminance stability and the effect of viewing angle on contrast. MfVEP responses were recorded from fifteen normal subjects and the SNRs and peak times of the responses compared.

The LCD monitor took longer to reach stable luminance than the CRT monitor and the final luminance varied with room temperature. Luminance and contrast were more uniform across the LCD screen than the CRT screen. Viewing angle had no effect on contrast for either.

Similar to previous studies with PVEPs this study found no significant difference in SNR between responses elicited by the two stimulators but found that responses to LCD stimulation were 11-13ms later.

Conclusions: LCD monitors may be used to elicit mfVEP responses but must have sufficient time to reach stable operating luminance and be used in a temperature-controlled environment. These results may reassure those already using LCD monitors as VEP stimulators and those considering replacing ageing CRTs with LCD monitors.

ICMP 2013

DAY 3, TRACK 5

EDUCATION CLINICAL TRAINING AND CERTIFICATION OF MEDICAL RADIATION PHYSICISTS

Invited Speaker

EDUCATION AND TRAINING REQUIREMENTS IN RADIATION PROTECTION FOR MEDICAL PHYSICISTS - RESULTS FROM THE MPE AND MEDRAPET PROJECTS

Carmel J. Caruana

Immediate Past Chair, Education and Training Committee, EFOMP

Medical Physics Department, Faculty of Health Sciences, University of Malta

The last few years have been decisive to the development of Education and Training for Medical Physicists and Medical Physics Experts in Europe. In particular, the 'Guidelines on the Medical Physics Expert' project has specified for the first time a comprehensive inventory of the learning outcomes (expressed in terms of knowledge, skills and competences as required by the European Qualifications Framework) for the Medical Physicist /Medical Physics Expert in the specialty areas of medical physics which involve ionizing radiation protection namely, Diagnostic and Interventional Radiology, Radiation Oncology and Nuclear Medicine. In addition a qualifications framework for the Medical Physics Expert has been stipulated which is more appropriate for the actual state of development of medical radiation technology and research. On the other hand, the MEDRAPET (MEDical RAdiation Protection Education and Training) project has specified learning outcomes (also in terms of knowledge, skills and competences) in radiation protection for both the physics and non-physics healthcare professions. Citing the MEDRAPET document: Medical Physicists and Medical Physics Experts have a special role in radiation protection which is 'special and wide-ranging' whilst for medical physicists the term 'continuous professional development' has a special meaning which is 'advanced education, training and experience for the achievement of MPE status in their particular specialty of medical physics'. This presentation will summarize the results of the two projects and present future directions.

* In Europe the word 'competence' has the meaning of 'responsibility and autonomy'.

Invited Speaker

IAEA INITIATIVES ON EDUCATION AND TRAINING FOR MEDICAL RADIATION PHYSICISTS

Ahmed Meghzifene

International Atomic Energy Agency

The shortage of medical physicists, insufficient education and training, and lack of professional recognition were identified as the main issues to be addressed by the IAEA. To address these issues, the IAEA developed a series of integrated projects aiming specifically at promoting the essential role of medical physicists in health care, developing harmonized guidelines on dosimetry and quality assurance, and supporting education and training. A unique feature of the IAEA programme is the support it provides for implementation of guidelines and education programmes in Member States through its technical cooperation programme. The IAEA support for education and training includes published self-study material (Handbooks), detailed guidelines on clinical training in radiation oncology, X-ray diagnostic radiology and nuclear medicine, fellowships covering both short-term training and long-term (academic/clinical training abroad), setting-up national/regional education programmes, and organizing training courses and workshops focussed on specific topics for continuous professional development of medical physicists. In the last decade the IAEA has published several technical reports and guidance documents that are a useful resource for medical physics training. The IAEA has also developed a website called Human Health Campus to serve as a resource for health care professionals and students in radiation medicine. With the aim to support international harmonization of the practice of medical physics, the IAEA has just published the Human Health Report Series No. 25 on the roles and responsibilities of clinically qualified medical physicists and their education and clinical training requirements. The IAEA report has been endorsed by the IOMP and AAPM.

Invited Speaker

CERTIFICATION OF MEDICAL RADIATION PHYSICISTS: DIFFICULTIES AND SOLUTION

Raymond K. Wu, PhD

University of Arizona Cancer Center, Phoenix, Arizona, USA

Chairman, IOMP Professional Relations Committee

IOMP adopted the Policy Statements 1 & 2 in May 2012 in Beijing during the World Congress. The role and responsibilities as well as the educational and training requirements are defined and outlined with some details. The statements are applicable to all medical physicists including those engaging in areas such as research and teaching. Many medical physicists are also engaged in clinical service as health professionals. Policy Statement 1 recognizes the Certified Medical Physicist as one who has the level of expertise to practice independently one or more subfields of medical physics in the clinical environment. The responsibilities involving clinical treatments or diagnostic procedures for patients are huge. The task of determining whether a person is able to shoulder such responsibilities is even more difficult. As epidemiology, culture, resources, and societal expectations are different in different populations, the job of an international certification body to design one process to fit all is not possible. However, it is important for the medical physics community in each population to strive for the best quality of practice consistent with the society as a whole. Therefore a model or models must be developed for the international certification body to carry out its mission. In this presentation, the general direction to resolve the issues will be presented, and the ways to align with current national certification programs will be addressed.

Invited Speaker

THE KEY ROLE OF MEDICAL PHYSICS EDUCATION AND TRAINING IN PATIENT PROTECTION

Teresa Eudaldo

Medical Physicist, Servei de Radiofísica i Radioprotecció, Hospital de la Santa Creu i Sant Pau. 08025, Barcelona, Spain.

Clinical medical physicists play a vital role in the healthcare team because they are actively involved in all fields that use ionization and non-ionization radiation. To prevent errors and even accidents, it is crucial that all professionals working in diagnostic and treatment procedures are well-qualified in terms of knowledge, skills and competences. Medical physicists are no exception.

The Directive 43/97 EURATOM already emphasized the importance of education and training. In 2011, the draft of a new Directive (the new BSS), defines the figure of “Medical Physics Expert”, and laid out their responsibilities within the healthcare environment, their involvement in clinical procedures with regard to patient protection, and the importance of education and training.

Nevertheless, as new technologies are constantly appearing in the medical environment, even a high level of initial qualification it is not sufficient to guarantee full professional competences for the long term. In the last few years medical physicists have to keep up with many changes, maintaining their professional competences at the highest level to guarantee the best patient protection in diagnostic and therapeutic procedures. To that end, continuous education is a crucial issue. Since 1999, EFOMP has been promoting continuous professional development (CPD) for medical physicists and giving recommendations for implementing national CPD schemes.

In conclusion, the competence of clinical medical physicists must be founded on three critical elements: a sound knowledge of medical physics, a formal period of clinical training, and a life-time structured continuous professional development. Only with this approach can we provide best practice and ensure maximum patient protection.

Paper Number: 0330

MEDICAL PHYSICS RESIDENCY PROGRAMME IN A RESOURCE CONSTRAINED SETTING:THE NIGERIA EXPERIENCE.

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The current trend in Radiation Therapy in developing countries is to deploy new equipment with advanced capabilities to narrow the gap with the state-of-the-art.

The equipment is only one component of the resources needed for its safe and effective utilization. Manpower training is probably the most critical element in the equation. The practical training of Medical Physicists is one of the major hurdles in making a safe transition possible in Africa. This training is typically achieved in a residency programme.

Typically these programmes evolve organically in large, well equipped and well staffed medical centres over a period of a decade or more.

In developing countries, there is commonly a shortage in all these three areas and the common situation does not allow the luxury of this length of times.

Against this background we shall discuss the experience garnered so far with the recently launched national medical physics residency programme in Nigeria.

We will discuss the features of the programme along with issues of institutional, national and international support, and its strengths and limitations.

We will present the main lessons and challenges learned so far in this programme.

ICMP 2013

DAY 3, TRACK 5

UK PROFESSIONAL ISSUES

ICMP 2013

DAY 3, TRACK 5

EDUCATION AND CPD FOR MEDICAL PHYSICISTS

Invited Speaker

IOMP MODAL CURRICULUM FOR POST GRADUATE EDUCATION PROGRAMMES IN MEDICAL PHYSICS

Slavik Tabakov

Vice-President IOMP, King's College London, UK

The IOMP Working Group developing this project include S Tabakov, P Sprawls, A Krisanachinda, E Podgorsak and C Lewis. Elements of the project have been also used in the current IAEA MSc Curiculum.

The IOMP Model Curriculum project aims to present guidance on the organisation of post-graduate (MSc level) courses on Medical Physics. The project presents several models for this: modular, distributed, mixed, topical and e-Learning. The advantages/disadvantages of these models are discussed from the point of view of specificity in the country. The aim of the project is to introduce criteria and method for IOMP international Validation of MSc courses in Medical Physics.

Based on assessment of many educational programmes from various countries, the project proposes indicative MSc curriculum outline with the following main modulese:

Basic modules: Basis of Human Physiology and Anatomy ~10%; Basis of Radiation Physics ~10%

Research Methods ~10%; Radiation Protection and Hospital Safety ~10%

Optional modules: Medical Imaging Physics (non-Ionising) ~10%; Medical Imaging Physics (Ionising) ~10%; Radiotherapy Physics ~15%; MSc project ~ 25%

The indicative content of the modules is presented, forming a total number of contact hours. The latter varies (according to local University requirements) from c. 1200 to c. 350 (in case of high self-reading expectation). The delivery of this education is linked with the Organisation of the MSc courses: staffing (local and external) and host University requirements. These are also linked with the requirement/method of IOMP Validation of the MSc course

The IOMP Model curriculum project will allow for a small country with limited expertise to set-up a post-graduate course in Medical Physics. This will boost the profession in many developing countries. Validating of new programmes will be made through the IOMP ETC Validation and Accreditation Panel – an international body of experienced professionals. This will assure the local University that the validated MSc programme is in line with the international standards.

The projects together papers about the educational experience from 26 countries (plus other Education and Training projects) is included in the book "Medical Physics and Engineering – Education and Training" – part I, available free from http://www.emerald2.eu/mep/e-book11/ETC_BOOK_2011_ebook_s.pdf

Invited Speaker

ACCREDITATION OF THE EDUCATION AND TRAINING IN MEDICAL PHYSICS: WHY AND HOW

John Damilakis, PhD

University of Crete, Faculty of Medicine, Heraklion, Greece

There is high demand for developing education and training courses in medical physics due to the rapid development of highly advanced medical technology in imaging and treatment of diseases. An increasing number of universities have in recent years started to offer undergraduate or postgraduate courses on Medical Physics. Moreover, Continuing Professional Development (CPD) for medical physicists is of great professional interest. The attendance of CPD courses has become an obligation for medical physicists to keep them up-to-date in their field. However, external assessment of the quality of education or training provision is needed. Accreditation is the formal recognition that education and training on medical physics provided by an institution meets acceptable levels of quality.

Accreditation should be based upon standards and guidelines. Requirements for accreditation of a training programme should take into account several aspects including facilities, staff, educational material and teaching methods. Training in medical physics should be provided in clinical facilities. An accreditation decision should be made following an on-site evaluation by a team of experts in the field of medical physics.

In Europe, ENQA (European Network for Quality Assurance) promotes European co-operation in the field of Quality Assurance in higher education. A European organization is needed to offer accreditation of medical physics training programs. CAMPEP (Commission on Accreditation of Medical Physics Educational Programs) promotes education of medical physicists in the USA by evaluation and accrediting graduate, residency and CPD programs.

Invited Speaker

CONTINUING PROFESSIONAL DEVELOPMENT SYSTEMS FOR MEDICAL PHYSICISTS

W.H. Round

School of Engineering, University of Waikato, Hamilton, New Zealand

Medical physicists must have access to continuing education and training after qualifying to ensure that they retain their capacity to practice safely, effectively and legally within their evolving scope of practice. Systematic ways of assessing and recording such activities are used in 26 countries as formal, structured continuing professional development (CPD) systems. They often used for certification, registration and license renewal purposes and they should be implemented in all countries where clinical medical physicists are employed.

A recent survey of CPD systems that are currently operated around the world showed that, in general, they are quite similar, although some have systems that differ significantly from the others in many respects. Generally they ensure that medical physicists are kept up to date, but there are some that clearly will fail to achieve that.

CPD is more than just continuing professional education (CPE). It can include research publication, working group contribution, thesis examination and many other activities. The survey categorized the different activities that are accepted as CPD and an analysis of what is required to construct a useful medical physics CPD system was carried out.

Medical physicists around the world do not all have sufficient access to the finance, time, and education/training expertise and resources to adequately engage in CPD. As a profession we must make it our responsibility to overcome their difficulties by sharing materials and by promoting cooperation among regional and global organizations to foster access.

ICMP 2013

DAY 3, TRACK 5

WORKSHOP ON MPE ROLE

ICMP 2013

DAY 4, TRACK 1

QA FOR DIGITAL RADIOLOGY MODALITIES

Invited Speaker

CLINICAL MEDICAL PHYSICS 2.0: A VISION FOR MODERN IMAGING ENTERPRISE

Ehsan Samei

Duke University, Durham, NC, USA

Diagnostic imaging has always been a technological highlight of modern medicine. Imaging systems, with their ever-expanding advancement in terms of technology and application, increasingly require skilled expertise to understand the delicacy of their operation, monitor their performance, design their effective use, and ensure their overall quality and safety, scientifically and in quantitative terms. Physicists can play a crucial role in that process. But that role has largely remained a severely untapped resource. Many imaging centers fail to appreciate this potential, with medical physics groups either nonexistent or highly understaffed and their services poorly integrated into the patient care process. As a field, we have yet to define and enact how the clinical physicist can engage as an active, effective, and integral member of the clinical team, and how the services that she/he provides can be financially accounted for. Physicists do and will always contribute to research and development. However, their indispensible contribution to clinical imaging operations is something that has not been adequately established. That, in conjunction with new realities of healthcare practice, necessitates a growing need to establish an updated approach to clinical medical imaging physics. This presentation aims to describe a vision as how clinical imaging physics can expand beyond traditional insular models of inspection and acceptance testing towards team-based models of operational engagement addressing topics such as new non-classical challenges of new technologies, quantitative imaging, and operational optimization, while speaking to new paradigms of comparative effectiveness and meaningful use.

Invited Speaker

LINEAR SYSTEM THEORY APPLIED TO IMAGE QUALITY METRICS

Nick Marshall

Department of Radiology, University Hospitals Leuven, Herestraat 49, 3000 Leuven, Belgium

The widespread introduction of digital imaging systems in radiology has given diagnostic radiology physicists access to digital data. This in turn has allowed the assimilation of advanced measures of detector and system performance into routine quality assurance (QA) and optimization. The IEC standards for measuring Detective Quantum Efficiency (DQE), together with the seminal work of Wagner and Brown and the "ICRU Report No. 54. Medical Imaging - The Assessment of Image Quality" have proved very influential in this respect.

This talk will briefly touch on the history and development of linear system metrics and their particular application to diagnostic radiology imaging systems. Modulation transfer function (MTF), noise power spectrum (NPS) and DQE are defined and applied to the evaluation of x-ray detector performance. The suitability of these metrics for routine use in QA programmes is then discussed. Recent work has concentrated on extending the DQE concept from a detector-based metric to parameters such as effective DQE (eDQE) and generalized DQE (GDQE) that characterize total system performance. Finally, we will examine the move towards a task based definition and evaluation of image quality, as described in ICRU Report 54.

Paper Number: 0072

COMPARISON OF VARIOUS DIGITAL DETECTORS IN TERMS OF DOSE AND IMAGE QUALITY

Manthos Koutalonis, Mandy Moreton, Adrian Porter, Ed Hogbin

Colchester Hospital University NHS Foundation Trust, Colchester, Essex, UK

The wide spread use of digital x-ray imaging systems in clinical practice in the last few years has allowed the use of objective image quality parameters, such as the Modulation Transfer Function (MTF), Noise Power Spectrum (NPS) and Detective Quantum Efficiency (DQE), as a means of evaluating image quality, in addition to the existing subjective ones, such as threshold contrast, spatial resolution etc. Various digital detectors are available for use today and Radiology departments can select from a variety of converting materials, pixel and detector sizes.

As part of an evaluation process performed in Colchester Hospital University NHS Foundation Trust, three digital detectors, Agfa DX-D 30C, Fuji D-EVO G35i and Carestream DRX-1 were compared in terms of their dose and image quality performance. Image quality tests, including objective and subjective metrics, were performed on the three detectors. The methods described in IEC 62220-1 and IPEM Report 32, Part VII were followed regarding the measurement of MTF, NPS and DQE.

The effect of the physical properties of the converting material used in each detector was apparent in the results. Agfa DX-D 30C uses CsI which can be produced in a needle sharp form, limiting scatter of light within the detector. Therefore, image quality results for this detector were very good. Fuji D-EVO G35i and Carestream DRX-1 use GdO2S2 as the converting material which is known to be noisier, resulting in a higher NPS and therefore lower DQE and degraded image quality when compared to CsI detectors.

Paper Number: 0168

A NEW SIMPLIFIED PRACTICAL METHOD FOR MEASURING THE PRESAMPLED MTF USING AN EDGE DEVICE

Yasuyuki Kawaji[1], Yoshihiko Onizuka[1], Fukai Toyofuku[2]

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We are proposing a new simplified practical method for measuring the presampled MTF of digital radiographic systems using a "virtual slit" image from an edge image. This method differs from previous methods in that it derives the Line Spread Function (LSF) without numeric differentiation of the Edge Spread Function (ESF). We analyzed the accuracy of the new method using both a mathematical image and a real x-ray image. In the simulation, the MTF obtained from the new method was in good agreement with the theoretical MTF (within 0.05%). The accuracy of the new method was superior to that of the IEC method at higher spatial frequencies greater than 5 cycles/mm. In the clinical system, both the MTFs of the new and the IEC methods are in good agreement for frequencies up to the Nyquist frequency limit (within 0.35%). The standard deviation (SD) in MTF of the new method was larger than that of the IEC method. However, the SD of MTF values of the new method was almost comparable to that of the IEC method by using the mean LSF - by averaging three LSFs. In our method, we can calculate the LSF from a "virtual slit" image and obtain a precise presampled MTF much more easily than in previous methods.

Paper Number: 0354

QUALITY IMAGE EVALUATION BY OBJECTIVE AND SUBJECTIVE ANALYSIS

Alexandre F.Velo[1], Diana R. de Pina[2], Sérgio M. Ribeiro[2], José Ricardo A. Miranda1

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The ionizing radiation methods still the most commonly used for being cheaper and very efficient. New systems were developed, like the Computed Radiography and Digital Radiography. The optimization of risk-benefit rate is considered a breakthrough in computed radiology, however it's not the reality of the computed and digital image, which do not have well established norms and protocols for image, dose and expense on the clinical routine.

This research had as objective the optimization of computed radiographic images of the chest (anterior - posterior projection). An homogeneous phantom that simulates spreads and absorption characteristics of radiation next to a standard patient, with 1,73 m and 75 Kg approximately was used to calibrate the computational image system, acquiring Agfa's exposure index (lgMs) to each kVp. These techniques were applied on an Anthropomorphic Phantom (RANDO). The images were evaluated by a radiology specialist whose identified the best image (optima image) for each kVp to determine possible anomalies on lung / bones lesions using the Visual Gradual Assessment (VGA).

Then the images were evaluated by physicals parameters, Modulated Transfer Function (MTF) and Detective Quantum Efficiency (DQE) using the software Matlab®, and compared with those evaluated by the observer.

Comparing the GS image to the commonly produced on clinical routine of the Hospital das Clínicas da Faculdade de Medicina de Botucatu (HCFMB - UNESP), the GS image presents better visualization quality, however the GS image presents dose and tube charge reduction on 70, 5 % and 80 % respectively when compared with the clinical routine.

Paper Number: 0321

QUALITY ASSURANCE TESTING IN DIAGNOSTIC RADIOLOGY – TO TEST OR NOT TO TEST; THAT IS THE QUESTION.

Aoife Gallagher[1], Anita Dowling[1], Una O'Connor[1], Louise Bowden[1], Ronan Faulkner[1], Jim Malone[2], Geraldine O'Reilly[1]

[1]St.James's Hospital, Dublin, Ireland, [2]Trinity College, Dublin, Ireland

X-ray technology has become increasingly more complex over the past 30 years. These technological developments however have not always been matched by a similar emphasis on updating Quality Assurance (QA) protocols to reflect the technical changes. Therefore many of the same tests undertaken 30 years ago are still routinely performed today.

Our Department has provided QA services to hospitals throughout the country since the 1980's and testing has been in accordance with international protocols and best practice guidance of the time. The equipment base tested in this survey ranges across all of the imaging modalities including fixed, mobile and dedicated chest systems, varies in age from one to 27 years and is now mainly based on CR and DR technologies. A review of recent QA results from 97 X-ray tubes from general radiographic systems is presented in this paper.

The results confirmed that while performance issues were identified at commissioning and towards "end of life", over 90% of systems were operating within remedial action tolerances for key tests (e.g. tube/generator performance) in the intervening period. Conversely, it was observed, that approximately 40% of the systems exhibited less than optimal performance in relation to the operation of the Automatic Exposure Control (AEC) function.

This survey provides valuable information which could be used to redesign QA programmes in order to ensure that available resources are applied to best effect. The findings may be of particular interest to those involved in the future development of QA programme guidance documents.

ICMP 2013

DAY 4, TRACK 1

NEW APPLICATIONS AND TECHNIQUES IN INTERVENTIONAL RADIOLOGY

Invited Speaker

SKIN DOSE MANAGEMENT – TECHNOLOGIES & APPROACHES

Mr Andrew Rogers

Head of Radiation Physics, Nottingham University Hospitals NHS Trust, Nottingham, UK

This presentation will review current methodologies for assessing patient skin dose in the context of emerging technologies such as new equipment standards, DICOM dose objects and patient dose software advances. Current skin dose estimates from recent literature will be reviewed to attempt to scope the scale of the issue and will end on a review of current approaches to the important issue of real patient management following a potential high skin dose procedure, focussing on trigger levels, patient recall and subsequent clinical management.

Paper Number: 0232

PATIENT SPECIFIC CALCULATIONS OR USING A GENERAL CONVERSION FACTOR TO ESTIMATE EFFECTIVE PATIENT DOSE IN INTERVENTIONAL CARDIOLOGY

Annelies Jacobs, Lieve Rens, Walter Desmet, Hilde Bosmans

UZ Leuven, Leuven, Belgium

INTRODUCTION

In interventional cardiology, different types of heart diseases are diagnosed and treated in a non-invasive way using X-rays. Aim of this work was to prepare patient dose monitoring by comparing Monte-Carlo based dose estimates to the use of conversion factors.

MATERIAL & METHODS

Data collection was performed on a Siemens AXIOM Artis dBC system. Data of 62 adult and 21 paediatric procedures were collected. Different methods to calculate patient effective dose (E) were compared: (1) published projection specific dose area product (DAP) to E conversion factors for cardiac procedures and reference persons; (2) a global conversion factor derived from (1); (3) a patient specific approach using a Monte-Carlo platform scalable to patient size (PCXMC).

RESULTS & DISCUSSION

Mean effective dose for adult patients with method (1) was 24.6mSv, 27.2mSv with method (2) and 28.4mSv with method (3). The global conversion factor obtained for adult patients was 0.33mSv/Gycm2 (SD 0.07).

A Student t-test showed a significant difference between methods (1) and (3) (p-value 0.0002). The average deviation between methods (1) and (2) was 22% (SD 7%).

For paediatric patients, the doses calculated with (1) and (3) differ by a factor of 3.1 (7.7mSv vs 23.8mSv). This illustrates the requirement for weight and size specific conversion factors.

CONCLUSIONS

For adult procedures, there was a significant difference between E calculated with conversion factors and with PCXMC. If deviations on E of 22% are acceptable, a global conversion factor can be used for dose monitoring. Specific paediatric conversion factors should be established.

Paper Number: 0271

PATIENT ENTRANCE DOSE RATES MEASURED ON A RANGE OF FLUOROSCOPY SYSTEMS FOR PHANTOM SIZES 20-30CM

Louise Bowden, Ronan Faulkner, Aoife Gallagher, Una O'Connor, Geraldine O'Reilly, Anita Dowling

St. James's Hospital, Dublin, Ireland

Recent studies show an increase of 25% in obesity in adults over the last decade. This increase in patient size has lead manufacturers of medical, including radiology, equipment, to adapt to the special requirements of larger patients. In addition, users of medical equipment may need to adjustment their typical set-up for these patient profiles.

For quality assurance testing of radiology equipment, patient doses are currently assessed using ~20cm thick phantoms to mimic the “standard” patient of ~70kg. In fluoroscopy, RP162 sets out a suspension tolerance 100mGy/min for the patient entrance dose rate (PEDR) with a standard size phantom. However, as patient size continues to increase, QA protocols may need to be adjusted and additional suspension tolerances may be needed to account for the range of patient sizes encountered clinically.

This study examines the PEDR in fluoroscopy examinations using phantom thicknesses of 20-30cm on 20 different fluosocopy systems.

With the typical 20cm phantoms, PEDR measurements averaged ~18mGy/min. Initial results showed that this increases to ~28mGy/min and 69mGy/min for 25cm and 30cm respectively. However, some modalities, especially those used for cardiac procedures, gave a PEDR of up to 130mGy/min for a 30cm sized phantom. These results highlight the sharp increase in doserate with larger phantoms and provide comparison values to allow for optimisation of similar systems. The results also show that future QA protocols may need to be amended and additional suspension tolerances will be needed so systems can be assessed across the complete range of clinically relevant set ups.

ICMP 2013

DAY 4, TRACK 1

PERSONAL DOSIMETRY IN INTERVENTIONAL RADIOLOGY

Paper Number: 0078

DOSE QUANTITIES FOR THE EYE LENS, THE EXTREMITIES, AND THE WHOLE BODY

Rolf Behrens

Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

In this work, it was investigated which type of dosemeter (i.e. which dose quantity) is suitable for which task of radiation protection monitoring[1].

Hp(0.07) dosemeters are constructed to monitor the local skin dose at a 0.07 mm depth as the radiation-sensitive epidermis lies about 0.07 mm below the surface. In pure photon radiation fields, e.g. in interventional radiology, they are also suitable to monitor the lens dose when worn near the eye and if the back of their case consists of thin plastic[2]. In beta radiation fields, e.g. in nuclear medicine, they may overestimate the lens dose by a factor of 100 or more. Thus, they are unsuitable here[1].

Hp(3) dosemeters are constructed to monitor the lens dose as the radiation-sensitive part of the lens lies about 3 mm within the eye. Only very few Hp(3) dosemeters exist, but, due to their construction, they should monitor the lens dose in beta fields correctly, too. However, this has not yet been demonstrated[3].

Hp(10) dosemeters are constructed to monitor the whole body dose as the inner organs are assumed to lie at least 10 mm deep within the body. In rather homogeneous and pure photon radiation fields of energies above about 40 keV and with the radiation mainly coming from the front, they may also be appropriate to monitor the lens dose when not worn below an apron[4].

LITERATURE

(see also www.ptb.de/en/org/6/63/f_u_e/f_u_e.htm#augenlinse):

[1] Phys.Med.Biol. 55 4047 (2010) and Phys.Med.Biol. 56 511 (2011)

[2] Rad.Prot.Dosim. 148 139 (2012)

[3] J.Radiol.Prot. 32 455 (2012)

[4] www.ptb.de/en/org/6/63/f_u_e/ts7e_3.pdf

Invited Speaker

MONITORING EYE LENS DOSE FOR INTERVENTIONAL CLINICIANS: THE PRACTICAL IMPLEMENTATION

Filip Vanhavere

SCK•CEN, Belgian Nuclear Research Centre

Cataract is the loss of transparency of the lens of the eye. It is known that cataract can also be radiation induced. The present annual dose limit for the eye lens for occupationally exposed workers is set to 150 mSv per year. A recent ICRP statement on tissue reaction recommends to reduce the limit to 20 mSv/year, averaged over a period of 5 years, with no single year exceeding 50 mSv. Especially in the medical field and more specifically interventional radiology/cardiology, this reduced dose limit might pose extra monitoring requirements.

During the ORAMED project (Optimization of Radiation Protection of Medical Staff) measurement data have been collected from 34 European hospitals covering almost 1300 procedures. In general, the doses to eye lens are low, but with great variability. The highest doses are found in embolizations, with a mean value of about 60 µSv per procedure. The annual eye lens doses depend largely on the workload and the protection measures used. The present dose limit of 150 mSv per year for Hp(3) is generally not reached. If the dose limit is reduced to 20 mSv, many physicians could surpass this limit, and therefore monitoring and the proper use of radiation protection equipment will even be more important.

Next to presenting some of the ORAMED data, this presentation will give some guidelines on when and how monitoring for eye lens dosimetry can be done. Such guidelines are now being elaborated in an ISO draft standard. A recent project called ELDO has shown that using the whole body dosimeter above the lead apron to estimate the eye lens doses will lead to large uncertainties. The major results from this ELDO project will also be presented.

Invited Speaker

WORKING TOWARDS AN ISEMIR INTERNATIONAL DATABASE FOR OCCUPATIONAL RADIATION PROTECTION IN INTERVENTIONAL CARDIOLOGY

J.C. Le Heron[1], R. Padovani[2], A. Duran[3], D.L. Miller[4], Sim Kui Hian[5], E. Vano[7], C. Lefaureg

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As part of the Information System on Occupational Exposure in Medicine, Industry and Research (ISEMIR) project, the Working Group on occupational exposures and radiation protection of staff in interventional cardiology (WGIC) was formed in 2009 to undertake activities focussed on improving the implementation of occupational radiation protection in interventional cardiology (IC). Two WGIC surveys have set the stage for the development of an ISEMIR international database.

A world-wide survey in 2009 concluded, inter alia, that there was room for significant improvement in the practice of occupational radiation protection throughout the world, and that obtaining reliable data from radiation protection regulatory bodies on occupational exposures in IC was difficult.

A second WGIC survey has shown that it is feasible to obtain data on occupational exposure in IC directly from IC facilities. For physicians, the mean occupational effective dose per procedure was about 10 μSv for interventional cardiologists and about 3 μSv for electrophysiologists. Both nurses and technicians had a mean occupational effective dose per procedure of a little less than 1 μSv. The facility-averaged occupational effective dose per procedure for qualified interventional cardiologists ranged from 0.9 to 75.8 μSv per procedure, indicative of the wide variation in radiation protection practice between the different IC facilities.

The ISEMIR database, currently under development, will provide an active tool for individual IC facilities to assess the level of, and hence guide, implementation of the radiation protection principle of optimization of protection at their facility. Once fully developed and populated, the database will support three broad types of analyses – occupational doses per procedure as a function of personnel and facility attributes (i.e. the circumstances of the occupational exposure); benchmarking of facilities and individuals; and trends with time.

Invited Speaker

PERSONNEL DOSIMETRY FORMULAE: MAKING THE BEST USE OF AVAILABLE DATA

Heiner von Boetticher[1], Jörn Lachmund[1], Wolfgang Hoffmann[3]

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In diagnostic radiology where personnel usually wear lead aprons, the individual monitoring of external exposure [personal dose equivalent Hp(10)] is frequently performed based on personal dosimeters worn on the body below the lead apron. Since this is the area that is protected, the effective dose (E) in most cases is underestimated. Estimation of E with single dosimeter measurements assumes an algorithm with the reading either divided (over-apron case) or multiplied (under-apron case) by a certain correction factor. The combination of one dosimeter worn below the apron and another one above the apron allows E to be determined more accurately (double dosimetry concept). Coefficients for the one-dosimeter and two-dosimeter situations are derived using organ dose conversion coefficients according to ICRP 60 and ICRP 103.

In a radiological department for three years over-apron personal dosimetry with a collar dosimeter was performed instead of the under-apron measurement as is usual in Germany. The effective dose of the personnel was determined with the correction factor derived; the results are presented.

Because of the lower detection limit the over-apron dosimetry provides a better measure of effective dose. Therefore a dosimeter outside the apron as a first dosimeter is proposed. If it is worn as a collar dosimeter, an assessment of the head/neck and eye dose is also possible. For more accurate assessment of E, double dosimetry is recommended with a high sensitivity dosimeter as the second one worn below the apron.

ICMP 2013

DAY 4, TRACK 2

EMERGING MRI

Invited Speaker

7T MRI – IS IT READY FOR THE CLINIC?

Penny Gowland

University of Nottingham, Nottingham, UK

Ultrahigh field MRI affords new opportunities but also presents new challenges. This talk will present technical solutions to some of the problems that have arisen at high field, such as problems related to RF inhomogeneity. It will also present recent results in neurology and psychiatry which show that ultrahigh field can provide new information in both clinical research and patient management.

Invited Speaker

NON-INVASIVE ASSESSMENT OF TISSUE FUNCTION AND METABOLISM USING HYPERPOLARISED MAGNETIC RESONANCE.

Martin Leach

Cancer Research UK and EPSRC Cancer Imaging Centre, Institute of Cancer Research and Royal Marsden Hospital, Downs Road, Sutton, Surrey, SM2 5PT, UK.

Imaging methods used in medicine provide methods of measuring morphology and abnormality in three dimensions with high spatial and contrast resolution (CT, MRI and US). Labelled radiopharmaceuticals can also assess transport, binding and a number of important metabolic processes (PET, SPECT). In addition to measuring water and fat in MRI, MRS enables chemically specific measurements of a range of nuclei and molecules in vivo, reporting on important metabolic pathways. Unlike other imaging techniques, MR can indirectly measure a range of tissue and molecular behaviour, together with the effects of endogenous contrast agents, due to their influence on water or metabolite properties. However MR measurements are often restricted due to low sensitivity, a function of the small population difference between spin states at equilibrium. Hyperpolarisation of the spin population can be achieved for a number of nuclei, transiently producing signal increases of the order of 10,000 times the equilibrium magnetisation, with the signal then decaying with the T1 relaxation time of the molecule. Hyperpolarisation can be produced by optical pumping, maintaining samples at very low temperatures, or by dynamic nuclear polarisation, depending on the target nucleus. The high signals generated can be applied to new measurements, such as imaging lung air spaces and air-lung interactions with high resolution using 3He and 129Xe; measuring enzyme activity in real time; monitoring important metabolic pathways and the effects of specific inhibitors by using 13C and 15N labelled compounds. These techniques combine functional and metabolic measurements with the excellent soft tissue contrast provided by MRI.

Paper Number: 0135

DAILY QA OF HYBRID MR-PET SCANNER BIOGRAPH MMR IN FUKUSHIMA MEDICAL UNIVERSITY

Hara Takamitsu[1], Kubo Hitoshi[1], Shimao Daisuke[1], Nambu Takeyuki[1], Ohnishi Takahiro[2], Shishido Fumio[1], Takenoshita Seiichi[1]

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PURPOSE

Hybrid MR-PET scanner, Biograph mMR (Siemens Healthcare®) have considerable advantages to integrating both modalities in a single scanner that enables truly simultaneous acquisition. However, it is necessary to perform the daily QA program in order to demonstrate its performance. Up-to-date, Biograph mMR has been installed in only 34 facilities all around the world. In Japan, Fukushima Medical University is the first facility. Therefore established daily QA program does not exist. We introduce the daily QA program that was developed by Fukushima Medical University.

METHOD

We have confirmed attenuation correction and normal operation check of the coil using Head coil, the body array coil by measurement of the SNR with the phantom as a dedicated QA work of the MR scanner. We also have normalized time alignment, the detector using a standard source as QA work on the PET scanner. Standard source and MRI phantom have been employed to confirm the simultaneous image acquisition of MRI-PET.

RESULT

By checking daily QA, it is possible to know the exact condition of MR-PET Biograph mMR in everyday operation. Detail data will be shown in the presentation. In addition, we point out the error of the scanner before patient examination to prevent the unexpected incident.

CONCLUSION

Routine QA of MR-PET Biograph mMR is properly working right now in Fukushima Medical University. In the future, it should be required to keep trying improvement of daily QA methods.

Paper Number: 0336

CAN MAGNETIC RESONANCE PULSE WAVE VELOCITY MEASUREMENTS CHARACTERISE AORTIC CARDIOVASCULAR DISEASE?

Deirdre B Cassidy[1], Stephen J Gandy[3], Patrica Martin[2], Richard S Nicholas[3], J Graeme Houston[1]

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INTRODUCTION

Pulse Wave Velocity (PWV) has recently been proposed as an imaging marker of arterial stiffness and can be quantified using cardiac-gated CINE phase contrast MR techniques acquired at two aortic locations. The aim of this study was to extend the 'standard' method to a multi-slice PWV assessment (calculated by interrogation of 6-8 different anatomical sites along the aorta) in order to investigate if PWV can be used as a distinguishing factor for patients with 'high risk' or 'known' cardiovascular disease compared to young healthy volunteers.

METHODS

Multi-slice phase-contrast MRA was performed on a Siemens 3T Magnetom Trio scanner, to determine PWV on three-clinical cohorts: (i) Young Healthy Normal volunteers (YHN) [n=10] (ii) Clinical High Risk volunteers (CHR) with increased BNP [n=10], and (iii) patients with known Peripheral Arterial Disease (PAD) [n=7].

RESULTS

The calculated mean MRI PWV for the YHN cohort (5.2 ± 1.1m/s) was significantly slower relative to patent populations; CHR cohort (8.0±1.4m/s, $p<0.05$) and the PAD cohort (9.4±4.1m/s, $p<0.05$). A spread of PWV values was apparent across the three cohorts, with the two patient groups showing a significantly elevated PWV. The larger standard deviation observed in the PAD group is suggestive of greater disease heterogeneity (atheroma burden) compared to the YHV and CHR cohorts.

CONCLUSION

PWV can be derived from phase-contrast MRA using multiple aortic flow waveforms in combination with intra-arterial distance measurements. The mean PWV was found to increase significantly with age and cardiovascular disease severity - i.e. the data are consistent with developing aortic stiffness.

Paper Number: 0180

USE OF THE ULTRASHORT ECHO TIMES (UTE) PULSE SEQUENCE IN THE MR-PET SCANNER BIOGRAPH MMR FOR ATTENUATION CORRECTION IN THE DEPICTION OF TENDONS OR LIGAMENTS

Hara Takamitsu[1], Ohnishi Takahiro[2], Nambu Takeyuki[1], Shimao Daisuke[1], Kubo Hitoshi[1], Ishii Shiro[1], Shisido Fumio[1], Takenoshita Seiichi[1]

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Short T2 components appear in highly ordered tissues such as tendons, and ligaments tissues that exhibit low signal contents in conventional imaging sequences. To image short T2 tissues, sequences employing ultrashort echo times (UTE) are required. However, this sequence is not available in most scanners. The hybrid MR-PET scanner Biograph mMR allows using UTE pulse sequence for MR data-based attenuation correction. We performed tests to image the shoulder, wrist, knee, leg ligaments and tendons by utilizing the UTE pulse sequence for attenuation correction.

As the results, we succeeded to depict the clear imaging of wrist tendon and leg tendon while tendons and ligaments of the knee and shoulder could not fully visualize due to their curvature. To our knowledge this is the first time it was possible to image the wrist and leg tendons by applying the sequence of UTE for attenuation correction of PET data.

Paper Number: 0224

ARTERIOLAR ELASTICITY OBTAINED FROM MAGNETIC RESONANCE SIGNAL FLUCTUATIONS IN THE HUMAN BRAIN

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INTRODUCTION

Arteriolar elasticity, the deterioration of which may predict the progression of dementia, is an important vascular property. We focused on arteriolar vasomotion driven by respiratory PaCO2 changes, and propose a new method to map arteriolar elasticity using magnetic resonance imaging (MRI).

MATERIALS AND METHODS

A single slice of a healthy volunteer's head was imaged by spin-echo echo-planar imaging pulse sequence under a 1.5-T MRI system. The time course data were Fourier-transformed to map the spectral intensities in the low-frequency (L: <0.1 Hz), respiratory (R: 0.2-0.5 Hz) and cardiac (C: 0.8-1.2 Hz) pulsation ranges. The L and R maps were both divided by the C map to obtain the L/C and R/C maps.

RESULTS AND DISCUSSION

Blood flow (F) is proportional to the product of blood pressure (P) and vessel volume (V). F varies blood oxygenation, causing signal fluctuation. The C map represents the product of V and fluctuations in P at cardiac frequencies: V(ΔP)c, and the R map represents the product of P and fluctuations in V at respiratory frequencies: P(ΔV)r. Therefore, the R/C map represents [(ΔV)r /V]/[(ΔP)c/P]; while (ΔP)c/P is global in the brain, (ΔV)r/V reflects the arteriolar elasticity. The R/C map was almost homogeneous with a standard deviation (SD) of 10%. The homogeneity deteriorated in the L/R map reflecting V changes caused by local neuronal activities at resting state; the SD of the L/C map increased to 13%. Arteriolar elasticity could be mapped by using the spectral analysis of MRI signal fluctuation.

Paper Number: 0227

VERIFICATION OF ATTENUATION CORRECTION IN THE HYBRID PET/MRI SYSTEM: DEPENDENCY ON SIGNAL-TO-NOISE RATIO OF MR IMAGES

Daisuke Shimao[1], Takamitsu Hara[1], Hitoshi Kubo[1], Takeyuki Nambu[1], Takahiro Ohnishi[2], Fumio Shishido[1], Seiichi Takenoshita[1]

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Following the successful clinical establishment of PET (positron emission tomography) / CT (computed tomography), clinical use of the hybrid PET/MRI (magnetic resonance imaging) system is also spreading. One of the advantages of PET/MRI is that MRI offers anatomical image information without risk to the patient from ionizing radiation. On the other hand, PET/MRI needs unique approaches for predicting the attenuation maps from MR images for attenuation correction (AC), which differs from that for PET/CT, in which attenuation information is directly acquired by a conversion related to radiation energy levels One of the commercial PET/MRI systems adopts tissue segmentation using MR images acquired by Dixon's method for tissue AC. This method allows for tissue segmentation of air, fat, muscle and lungs, but not bone. We hypothesized that this segmentation method for tissue AC would be affected by the degree of signal-to-noise ratio (SNR) of the MR images used for the segmentation. To evaluate this hypothesis, some image sequences, which produce MR images with different SNRs, were made and used to scan healthy human volunteers both with and without the use of body array coils. All of the scans with body array coils successfully segmented the four kinds of tissues, while scans with only gantry coils failed the segmentation at a decrease in SNR of more than 25% from the recommended value. This indicates that we need to pay attention to the SNR for the AC sequence in some cases.

ICMP 2013

DAY 4, TRACK 2

ROLE MEDICAL PHYSICS IN REGULATORY PROCESSES (EFOMP)

Invited Speaker

OVERVIEW OF REGULATORY REQUIREMENTS FOR MR IN EUROPE

Stephen Keevil

Department of Medical Physics, Guy's and St Thomas' NHS Foundation Trust

Most European countries (with some exceptions) do not currently have specific legislation regulating the use of MRI or of electromagnetic fields (EMF) in general. However, a number of pieces of EU legislation do have implications for MRI. The Health and Safety Framework Directive (1) requires employers to conduct risk assessments, adopt protective measures, and provide workers with adequate training. This applies to MRI as much as to any other occupational sector. The Medical Devices Directive (MDD) (2) requires all medical devices placed on the market in the EU to obtain a CE mark, and demonstration of safety is one of the essential requirements for this. Compliance is normally established through IEC 60601-2-33 (3) and associated standards. The MDD will shortly be replaced by a new Medical Devices Regulation to promote greater uniformity across the EU (4). After several years of campaigning, the EMF Directive (5) has now been modified, with a derogation for MRI under certain conditions (6), the implications of which have yet to be established. It will be implemented in EU member states by July 2016. There are also a number of international standards and guidelines relevant to MRI. In this presentation, an overview of legislation and guidance and its implications for MRI will be given, with an emphasis on the new EMF Directive.

1. Directive 89/391/EEC.

2. Directive 93/42/EEC.

3. International Electrotechnical Commission. IEC std 60601-2-33, 3rd edition. Geneva: IEC, 2010.

4. Details available at http://ec.europa.eu/health/medical-devices/documents/revision/index_en.htm

5. Directive 2004/40/EC.

6. Available at http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P7-TA-2013-0243+0+DOC+XML+V0//EN&language=EN, formal publication expected 1st July 2013.

Invited Speaker

AN APPROACH TO SAFETY MANAGEMENT IN MRI

Prof Jeffrey Hand

Institute of Clinical Sciences, King's College London, London, UK

It is essential to ensure the safety of staff, patients, volunteers, and visitors within the MR environment. A 2-level approach to the management of MRI Safety which distinguishes between the roles of the person responsible for MR safety on a day-to-day basis (the MR Safety Officer) and those of an expert level professional with a higher degree of scientific and technical expertise in MRI (the MR Safety Expert) is suggested. This approach is a step towards harmonisation of safety of workers, patients, and the general public regarding the use of magnetic resonance imaging systems in diagnostic and interventional procedures.

Invited Speaker

FROM ESMRMB MEETING SAFETY AND TRAINING REQUIREMENTS IN MR IN EUROPE

David G Norris

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Safety and training requirements in Europe for MRI vary greatly between the countries of the EU. However, with the implementation of the Physical Agents Directive, and its derogation for MRI, guidelines for good practice will be introduced. The form that these will take is at present unspecified, but it would be surprising if they diverged greatly from previous recommendations, in particular the good practice guidelines implemented in The Netherlands. These describe the potential hazards of MRI equipment and define safe working practices that as a precautionary measure aim to minimise exposure to magnetic fields for the operator. In addition to agreeing good working practice, it will also be necessary to standardise training levels within Europe, and here the scientific community, and in particular the MR-based societies can play an important role in providing and harmonising training schemes. A likely outcome is that two levels of training will be defined: that necessary for safe operation of MRI systems in routine practice, and a second, which will have expert knowledge on non-standard situations, advanced investigations etc. The precise levels of knowledge required for the two levels remains to be clarified. This must clearly be compatible with patient and operator safety, but also be implementable in the diverse healthcare scenarios that exist in Europe, ranging from world-leading clinical MRI centres, to isolated radiological practices. The coming years will reveal the expectation that the EU has from the MR-community, and the way in which the community responds by establishing internationally recognised training schemes.

ICMP 2013

DAY 4, TRACK 2

GREGARIOUS MRI

Invited Speaker

HYBRID PET/MRI: QUO VADIS?

Simon R. Cherry, Ph.D.

Departments of Biomedical Engineering and Radiology, University of California, Davis

Highly sophisticated imaging systems that integrate positron emission tomography (PET) and magnetic resonance imaging systems (MRI) have recently emerged with astonishing speed, building on many years of technical development and catalyzed by advances in photodetector technology as well as the success of hybrid imaging with PET/CT. This presentation will trace some of the early developments in PET/MRI instrumentation, as well as review current systems and new systems currently under development. The use of approaches to PET/MRI based on photomultiplier tubes, avalanche photodiodes and silicon photomultipliers will be contrasted, and trade-offs in using each technology discussed. Early applications of hybrid PET/MRI technology, for both preclinical and clinical studies, will be shown. The remaining limitations of current generation clinical and preclinical PET/MRI systems will be identified and a view on the future needs and possible trends for instrumentation in PET/MRI presented for discussion.

Paper Number: 0329

THE FATTY HEART: CMRI STUDY OF DIABETES AND CARDIOVASCULAR DISEASE

Deirdre B Cassidy[1], Stephen J Gandy[3], Patrica Martin[2], Richard S Nicholas[3], J Graeme Houston[1]

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INTRODUCTION

Visceral obesity is associated with an adverse metabolic and cardiovascular risk profile. Myocardial fat deposited around the heart can be subdivided into epicardial adipose tissue (EAT) and pericardial fat. The purpose of this study was to measure the extent of EAT in a type-2 diabetic (T2DM) population with cardiovascular disease (CVD) using MRI and to correlate these measures with pulse wave velocity (PWV), an index of arterial stiffness.

METHODS

Fifty-patients were recruited into four groups: (G1) T2DM with CVD, (G2) T2DM without CVD, (G3) No T2DM with CVD and (G4) healthy controls. CMR assessment was performed on a Siemens 3T Magnetom-Trio scanner. The EAT region was derived from a cardiac-gated 2D-CINE segmented TrueFISP sequence, acquired in the four-chamber orientation. Manual contouring was performed at end-diastole phase. The PWV was calculated from free-breathing CINE phase-contrast MRA (PC-MRA) sequence at two slice locations, axial through the aortic arch, and at the descending aorta above the renal arteries. The temporal resolution was 128 phases per cardiac cycle with through-plane velocity encoding of 150cm/sec.

RESULTS

EAT was found to be significantly different between the patient groups (G1;5.32±1.9cm2, G2;4.52±2.07cm2 and G3;4.98±1.80cm2) and controls (G4; $p<0.001$). However, no differences were found between patient groups. PWV values in CVD groups (G1;8.42±2.55m/s and G3;8.98±3.14m/s) were found to be significantly higher ($p=0.03$, $p=0.02$) than healthy controls (G4) but not in T2DM (G2).

CONCLUSION

In this study, EAT was found to be associated with CVD and T2DM whereas arterial stiffness showed a relationship with CVD but not solely T2DM.

Paper Number: 0197

COULD TEXTURE ANALYSIS A USEFUL TOOL IN THERAPEUTIC TREATMENT DECISIONS IN BREAST CANCER PATIENTS? PRELIMINARY RESULTS

Shelley Waugh[1], Richard Lerski[1], Alastair Thompson[2]

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PURPOSE

Recent trends in breast cancer management are towards patient-tailored treatments based on molecular subtyping of breast lesions. The main subtypes (Luminal A (LumA),Luminal B (LumB(1)/LumB(2),overexpressed HER2 (HER2) and Basal) exhibit distinct growth patterns and indicate a different treatment regimen.

Previous reports suggest MRI texture analysis (TA) can be used in classification of cancer subtypes. This pilot study considered if TA could classify breast lesions into molecular subtypes, based on different growth patterns.

METHODS

Patients underwent breast MRI (post-biopsy) on a 1.5T Siemens Avanto scanner. Lesion molecular subtypes were obtained from the pathological reports. TA using co-occurrence matrix features was carried out using MaZda. Feature classification was performed, with classification accuracy and ROC area used to measure successfulness. Statistical assessment of raw feature values was also assessed (significance: $p<0.05$).

RESULTS

197 lesions from 130 patients were included (95 LumA,16 LumB(1),31 LumB(2),31 HER2,24 Basal). Results indicated good pair-wise classification for LumA and LumB(1) with all other subtypes (accuracy>78%;ROC>0.778). When all molecular subtypes were considered together, 2/3 of data was classified correctly (ROC=0.76). Of the 220 texture features, 193 were found to be significantly different between all groups (Kruskal-Wallis). In pair-wise comparisons, LumA and LumB(1) demonstrated the most features significantly different between paired groups (Mann-Whitney U).

CONCLUSIONS

These preliminary results suggest there are significant textural differences in the molecular subtypes of breast cancer, which are most likely to be attributed to different underlying growth patterns. This pilot work warrants further investigation into whether TA could potentially be a useful image-based diagnostic tool.

Paper Number: 0066

APPLICATION OF IQWORKS FOR QUANTITATIVE IMAGE ANALYSIS OF SPATIAL RESOLUTION IN MRI USING MODULATION TRANSFER FUNCTION (MTF)

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QA of MRI spatial resolution often uses two qualitative analysis methods for test object (TO) bar groups: subjective user decision of whether bars are resolved, and calculating modulation from a profile through them. Aliasing patterns and/or Gibbs' ringing may impede interpretation. Here, spatial resolution was assessed using quantitative methodology.

A Eurospin TO4 was imaged with a Spin Echo sequence (TR/TE/flip-angle: 1000ms/30ms/90o, single acquisition, slice thickness 5 mm, FOV 250mm, using both 2562 and 5122 matrices). In IQWORKS analysis was specified interactively as analysis trees, with the 'Edge/Line MTF' module processing data from the MTF block. The block's outline was detected automatically and at predefined positions around each of the 4 edges an Edge Response Function (ERF) was generated, and its calculated first derivative, the Line Spread Function (LSF) computed, then smoothed using a Moving Gaussian Weighted Polynomial algorithm. Results comprised the LSF's Full Width Half Maximum (FWHM) and the spatial frequency at which the MTF (the LSF's Fourier Transform) fell to 0.5, MTF (0.5).

Results were obtained from eleven different scanners. For 256 and 512 matrices, FWHM results ranges were (0.89 to 1.39) and (0.57 to 0.70) mm, and MTF (0.5) results ranges were (0.36 to 0.56) and (0.72 to 1.01) lp/mm. No difference was found for separately-recorded phase and frequency encoding directions.

The LSF's FWHM was comparable to pixel-size (0.98, 0.49mm for 256, 512 matrices), as expected. Gibbs edge ringing on the MTF block in some images may have degraded the ERF, increasing uncertainty in MTF values.

Paper Number: 0111

ASSESSMENT OF VELOPHARYNGEAL CLOSURE AND SOFT PALATE ANATOMY USING MRI IN CLEFT PALATE PATIENTS

Marc Miquel[1], Marie Pinkstone[2], Christoph Theopold[2], Marzena Wylezinska-Arridge[1], Malcolm Birch[1], Andrew Scott[3]

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INTRODUCTION

Assessment of soft-palate motion (velopharyngeal closure) is performed using x-ray videofluoroscopy or nasendoscopy to guide and evaluate cleft-palate repair surgery. The superior soft-tissue contrast of MRI provides detailed anatomical images. However, dynamic studies of the soft-palate have so far been limited by low temporal resolutions and/or only performed in healthy subjects.

OBJECTIVE

To develop an MRI protocol for use in assessing velopharyngeal closure during speech and evaluating the associated musculature.

METHODS

Subjects were imaged using a 1.5T Philips Achieva scanner. The three stage protocol was developed on 20 adult volunteers and applied to 10 patients (age 7-57 years). It comprised of:

1. Anatomical imaging (proton density-weighted turbo-spin-echo (TSE));
2. Real-time speech assessment (balanced steady-state-free-precession or hybrid echo planar imaging, ≥10 frames.s-1) in planes similar to videofluoroscopy and nasendoscopy;
3. Imaging during extended phonation ("ah"/"ee", TSE).

Speech tasks included counting and clinical test sentences. Speech audio was recorded using a fibre-optic microphone and synchronised movies were created off-line.

RESULTS

Imaging was successful in 9/10 patients; in one, the scan was aborted due to susceptibility artefacts caused by orthodontics devices. Using the real-time sequences, it was possible to perform a speech therapist lead evaluation of velopharyngeal function. The muscular anatomy of interest, including the levator veli palatini could be visualised from the proton-density TSE images. Total examination time was ~30minutes.

CONCLUSION

A comprehensive MRI protocol, including speech assessment, was developed and successfully applied to cleft-palate patients. Further data acquisition and analysis is under way to finalise its translation into clinical practice.

Paper Number: 0148

REPRODUCIBILITY OF APPARENT DIFFUSION COEFFICIENT MEASUREMENTS: RELIABILITY IN A CLINICAL SETTING

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PURPOSE

Diffusion Weighted Magnetic Resonance Imaging (DWI) is utilised in breast MRI for lesion characterisation and chemotherapy response assessment. There is no consensus as to the most reproducible measurement for reliable, accurate apparent diffusion coefficient (ADC) measurements. This work considered intra- and inter-observer variability of two methods of ADC measurements in patients with newly diagnosed breast malignancies.

METHODS

This study included 41 patients with proven breast cancer. Imaging was performed on a 1.5T Siemens Avanto scanner using a dedicated bilateral breast coil. ADC maps were produced from DWI with b-values of 50 and 800 s/mm2 (in-plane resolution: 1.8×1.8 mm2).

One technical and one clinical observer performed analysis using a Kodak Carestream workstation. Whole tumour ADC (ADCWT) was obtained by drawing around lesions on the slice with maximum dimension. Lowest ADC (ADCmin) was determined by moving 3mm2 ROI's within this boundary. Both observers repeated measurements one week later. Reproducibility was assessed using Bland-Altman plots, coefficients of reproducibility (CoR, units in mm2/s) and intra-class correlation coefficients (ICC).

RESULTS

ADCWT showed excellent reproducibility between readers (CoR=0.363; ICC=0.939), with slightly poorer results for ADCmin (CoR=0.120; ICC=0.872).

Intra-observer reproducibility was excellent for both readers. ADCWT was slightly better (technical/clinical: CoR=0.113/0.220; ICC=0.983/0.980) than ADCmin (technical/clinical: CoR=0.131/0.177; ICC=0.976/0.972).

CONCLUSIONS

ADCWT is more reproducible than ADCmin, likely due to the small ROI being more influenced by tumour heterogeneity and artefact. The technical observer demonstrated higher reproducibility, but results were consistent between observers.

In lesion characterisation and treatment monitoring ADCWT is likely to represent a more reliable measure of diffusion characteristics.

Paper Number: 0308

A NEW PHANTOM FOR THE ASSESSMENT OF MR RELATED GEOMETRIC DISTORTIONS AFFECTING GAMMA KNIFE RADIOSURGERY

Eleftherios Pappas[1], Argyris Moutsatsos[1], Ioannis Seimenis[2], Efstratios Karavasilis[1], Michael Torrens[3], Evangelos Georgiou[1], Pantelis Karaiskos[1]

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PURPOSE

Gamma Knife (GK) is regarded as one of the golden standards in terms of mechanical accuracy. However, the total GK spatial dose delivery accuracy may be deteriorated due to geometric distortions inherent in the MRI session necessitated for target localization and delineation. This work introduces a GK-tailored phantom capable of assessing MR related geometric inaccuracies.

MATERIALS AND METHODS

A custom plexiglass phantom has been developed to accurately fit to the Leksell stereotactic frame. 947 3mm-diameter holes lying on axial, coronal and sagittal planes, outspreading at the far off of the stereotactic space, serve as control points. The reversed read gradient technique was used to assess machine-related spatial distortions (i.e. B0 inhomogeneity and gradient nonlinearity). In-house software was used to locate the 3D coordinates of each of the control points identified in both MR and CT scans of the phantom. A distortion map was created by evaluating coordinate results for both MR and CT scan data. Moreover, the phantom can incorporate inserts facilitating assessment of other parameters such as signal homogeneity and low- and high-contrast resolution.

RESULTS

MR distortion owing to B0 inhomogeneity was found to be of the order of 0.5mm. Gradient nonlinearities induce geometric inaccuracies of up to 0.5mm. Total geometric distortion was found to be dependent on the read gradient direction, but not exceeding 1mm.

CONCLUSION

The proposed phantom can reliably evaluate the machine-related geometric distortions inherent in the MR images used for GK treatment planning.

ICMP 2013

DAY 4, TRACK 3

ADVANCES IN RADIONUCLIDE THERAPY

Invited Speaker

TARGETED RADIOTHERAPY OF PROSTATE CANCER

Robert J. Mairs[1], Colin Rae[1], Uwe Haberkorn[2] and John W. Babich[3]

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Trofex, a glutamate-urea-lysine tripeptide has high affinity for prostate-specific membrane antigen (PSMA) and has recently demonstrated exquisite specificity for PSMA-expressing, metastatic prostatic carcinoma. Preliminary imaging studies in patients, using [123I]Trofex, revealed tumour-selective binding and prolonged retention only in malignant sites. This indicates the therapeutic potential of this agent when labeled with Iodine-131. Our aim is to make the most effective use of [131I]Trofex for the treatment of metastatic prostate cancer by combining the [131I]-labelled radiopharmaceutical with radiosensitiser drugs. The compounds will be examined singly and in combination for their ability to sterilise clonogens derived from prostatic carcinoma cell lines using two- and three-dimensional in vitro models. Employing in vitro and in vivo systems, we will evaluate [131I]Trofex and synergising drugs (inhibitors of checkpoint kinase, PARP1, Hsp-90, Aurora kinase) for anti-tumour effect. Mechanisms of drug interaction will be determined and the most effective schedules of therapeutic agents will be evaluated in patients.

Paper Number: 0264

KEEP CALM AND CARRY ON... TREATING. HOW TO PROVIDE A QUALITY RADIONUCLIDE THERAPY SERVICE: PHYSICIST'S PERSPECTIVE.

Richard Fernandez

Guy's & St Thomas' NHS Foundation Trust, Lonon, UK

Radionuclides have been used for therapeutic applications since the turn of the twentieth century. The range of therapeutic applications, radionuclides, and methods of delivery have increased both in number and complexity in recent years.

Given that Radium was one of the first radionuclides purported to have health benefits, radionuclide therapy has seemingly come full circle with the imminent introduction of alpha emitters such as Ra-223 (for palliation of bone metastases) into routine clinical practice.

This paper, which was an invited lecture at the 2013 British Nuclear Medicine Society annual meeting, details how Physicist's involvement is essential for ensuring the safe introduction of new/novel therapies into routine clinical practice.

Key aspects to ensuring the delivery of a quality radionuclide therapy service will be discussed. These include:

radiopharmecutical delivery and administration

traceable calibration to a national standard

complexities of regulatory requirements, e.g. Environmental Permitting Regulations 2010

design and designation of areas

appropriate inpatient facilities and personal protective equipment

requirement for multi-disciplinary approach

Case study examples of challenging patient treatments/incidents (complex from both a clinical and radiation protection point of view), which were successfully managed through Physicist involvement/intervention will be discussed and teaching outcomes highlighted.

Paper Number: 0345

TECHNETIUM-99M-METHOXYISOBUTYLISONITRILE (99MTC-MIBI): A PREDICTOR FOR THE MANIPULATIONOF ANTIHORMONAL THERAPY IN RESISTANT HUMAN BREAST CANCER IN VITRO

Khalid Arif[1], Issam Hussain[1], Joanne Kerry[2], Philip Cosgriff[2], Carol Rea[1], Mohamed El-Sheemy[1], Mohamed El-Sheemy[3]

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INTRODUCTION

Tamoxifen is the most commonly used anti-hormonal therapy for oestrogen receptor positive (ER+) breast cancer patients. Ineffective tamoxifen and developing resistance to it remains a dilemma. Resistance may be associated with the presence of stem cell subpopulation (SP) and over expression of P-glycoprotein (P-gp) resulting in increased efflux rate. We previously reported a relationship between ABC- transporter protein and 99m Tc-MIBI efflux rate.

The aim: was to study the effect of anti-stem cell factor on tamoxifen efficacy in a breast cancer resistant cell line, monitored by 99m Tc-MIBI.

METHOD

Three breast cancer cell lines; wild type (sensitive) MCF7/WT, tamoxifen resistant MCF7/Tmx and MDA-MB-231 (ER–), were used. Flow cytometry was used to evaluate P-gp expression and stem cell surface markers CD24 and CD44. Cells were treated with 4- hydroxitamoxifen in the presence or absence of anti-stem cell factor and stem cell factor. Influx/efflux rates were monitored using 99m Tc-MIBI at different time intervals.

RESULT

Results shows positive expression of P-gp and CD44+/ CD24-/low in MDA-MB-231 and MCF7/Tmx. The influx/efflux rate of 99m Tc-MIBI is increased in all cell lines in the presence of anti-stem cell factor.

CONCLUSION

This study showed that anti-stem cell factor enhances anti-tumour activity in as determined by 99m Tc-MIBI. These findings may have implications for use of anti-stem cell factor with anti-hormonal therapy

Paper Number: 0390

QUALITY CONTROL TESTING OF ^{32}P LABELED ALBUMIN PARTICLES FOR INTERNAL RADIOTHERAPY OF REFRACTORY SOLID TUMORS

Shanaz Tolooee[1], Hosein Poorbeygi[1], Shahab Sheybani[1], Mahasti Amoui[2], Ahmad Bitarafan-rajabi[3], Mohammad Mazidi[1], Yaser hosein Tavakoli[1], Amir Darbandi Azad[3]

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^{32}P labeled albumin particles utilizing in therapeutic methods for inoperable solid tumors with remarkable vascularization. A process for preparing ^{32}P labeled albumin particles was developed by combining biocompatible Human Serum Albumin and ^{32}P phosphoric acid salt. Factor affecting the interaction process were investigated and labeling conditions optimized. Several tests for determination of size distribution, shape and radiochemical stability of particles were performed. The biodistribution of the particles was examined with after intravenous injection in Wistar rats. Studies for in vivo stability and distribution of radioactive pharmaceutical in animals such as mice and rabbits were evaluated with different administration methods using imaging techniques. Ten patients with variable types of hepatic tumors treated with intra-arterial injection of ^{32}P were included in this study. Optical microscopic examinations revealed that the particles have narrow size distribution with mean diameters of 20- 50 µm after sterilization and dispersing in a mixture of normal saline and HSA and or Tween 80 solution. The particles prepared have maximum with high radiochemical stability and purity of 99%.Tissue distribution in mice and Wistar rat and static images of ^{32}P/^{99m}Tc particles using gamma camera showed that high radioactivity accumulated in the lung as a vascular tumor model. CT and Bermsstrahlung SPECT of radioactive particles after radioembolization of hepatic in rabbit obtained with good biological and radiochemical stability. Albumin ^{32}P particles are useful nuclear medical therapeutic agents for producing localized radiation effect after interstitial injection or in methods using selective catheter placement in the supplying blood vessels of tumors.

ICMP 2013

DAY 4, TRACK 3

QUANTITATIVE INTERNAL RADIATION MEASUREMENT

Invited Speaker

MODELS AND TOOLS USED IN THE CALCULATION OF INTERNAL DOSE

Dr Glenn Flux

Royal Marsden Hospital and Institute of Cancer Research, London, UK

Treatment with radiopharmaceuticals has been performed for over 60 years. To date, standard practice has involved administration of fixed activities, sometimes modified according to patient or body surface area. In an emerging era of personalised and evidence-based medicine molecular radiotherapy (MRT) offers an unrivalled opportunity to tailor treatments according to the individual, based on the hypothesis that it is the delivery of radiation dose to tumours and to organs-at-risk that influences outcome, rather than the level of activity administered. Conventionally absorbed doses are calculated according to the MIRD schema, initially constructed to evaluate the absorbed doses delivered from diagnostic procedures. Dosimetry has been performed based on idealised models. Personalised dosimetry is now feasible, based on individual measurements of uptake and retention for which quantitative imaging is essential. This will be reviewed. Tools are also now emerging to allow voxelised dosimetry calculations which allow the determination of the heterogeneity of absorbed dose distributions that can in turn produce dose volume histograms and feed into radiobiological modelling. This will lead to individualised treatment planning, directing the radiopharmaceutical used and the frequency and timing of administrations. It can be predicted that the adoption of such practices will allow MRT to take its place alongside external beam radiotherapy as a key element of cancer treatment in number of treatments.

Invited Speaker

RADIONUCLIDE DOSE CALIBRATORS: CALIBRATION AND QUALITY CONTROL

Dr John Keightley

National Physical Laboratory, Teddington, UK

Radionuclide calibrators (or dose calibrators) are widely used in nuclear medicine to make activity measurements during the production of or before delivery of radiopharmaceuticals. These instruments usually comprise “re-entrant” ionization chamber coupled to display of the current produced in the chamber by the source under measurement, which is ultimately translated into an estimate of the source activity via a radionuclide/geometry specific calibration factor (or dial setting).

Related to the establishment and use of appropriate calibration factors is maintenance of the instrument on which they are used and establishment of an appropriate quality control program. These programs are designed to identify problems with radionuclide calibrators before they impact measurements used prior to administration to a patient. These QC measurements include calibration, measurements of constancy, and measurements of the linear range of activities that can be measured.

Good measurement practice (and in some countries, regulatory guidance) dictates that measurements performed using these instruments be traceable to national standards for the measurement of activity, and fall within an acceptable range of deviation from the “true” activity. The range of allowable deviation is typically from 5 - 10 % for therapeutic agents and may be higher for some diagnostic agents.

The use of radionuclide calibrators in nuclear medicine has been investigated for many years through the use of measurement comparisons or by proficiency testing. Participation in such exercises, coupled to a robust quality assurance program using standards traceable to a National Metrology Institute (NMI) gives the user confidence that the administered dose is within the prescribed limits. This manuscript summarises recent activities in the UK (and worldwide) to provide up-to-date guidance on the quality controls that should be undertaken to demonstrate traceability and accuracy of routine measurements in the field.

Paper Number: 0195

THE IMPORTANCE OF SCATTER CONTRIBUTION IN IMAGE QUANTIFICATION FOR RADIONUCLIDE THERAPY

Jill Tipping[1], Andrew Robinson[2], David Hamilton[1], David Cullen[2]

[1]The Christie NHS Foundation Trust, Manchester, UK, [2]Department of Physics and Astronomy, University of Manchester, Manchester, UK

Accurate dose quantification is essential for optimising the treatment of patients using Targeted Radionuclide Therapy (TRT). The calculation of patient-specific dosimetry for TRT is also a legal requirement in many countries throughout the EU.

The contribution of scatter to the image can be considerable when the imaging is undertaken using therapeutic radionuclides. Current scatter correction techniques in SPECT can cause the quantification of activity and therefore estimation of dose to vary by over 40%. For TRT radionuclides, which have significant gamma and beta emission branches (eg, 177Lu - an emerging TRT radionuclide which has shown very promising results in the treatment of neuroendocrine tumours) accurate scatter correction is especially problematic.

Monte Carlo simulation of a SPECT acquisition is a powerful tool for the characterisation of the scattering component arising from both direct gamma emission and beta induced bremsstrahlung radiation. Data from an ongoing programme of work using Monte Carlo simulation to characterise the scattering in SPECT imaging of 177Lu in phantoms, using activity distributions corresponding to patient therapies, will be presented. Improvements in activity quantification and image quality when using Monte Carlo simulation derived scatter corrections will be discussed and the potential effect on subsequent dosimetric calculations demonstrated. Results showing a potential six-fold improvement in scatter reduction, compared to the conventional Triple Energy Window methodology for 177Lu, will be reported.

Paper Number: 0388

MONTE CARLO CALCULATION OF THE SENSITIVITY OF A DOSE CALIBRATOR FOR 32P AND 90Y

Hosein Poorbeygi, Shahab Sheibani, Somayeh Moradi

Nuclear Science and Technology Research Institute, Tehran, Iran

The increased use of beta emitting radionuclides for therapeutic and palliative treatments necessitates accurate activity measurements. It is desirable to use dose calibrators for this purpose because they are convenient to use and readily available in nuclear medicine laboratories. For accurate activity measurements, calibration factors specific to the radionuclide, container type (syringe or vial), and measurement geometry must be applied. In this study, the detection process used in a commercial dose calibrator (Atom Lab) was modeled using MCNP Monte Carlo code with*F8 tally. The maximum variation in efficiency over the range of parameters was evaluated for mono-energetic electrons from 100 keV to 2.5 MeV, and for two pure beta-emitting, 32P and 90Y. The result shown that dose calibrator efficiency increases continuously as a function of electron energy from 100 keV to the energy needed for primary electrons to reach the gas volume (about 2.5 MeV). Above this threshold, efficiency increases abruptly due to electrons depositing their energy directly in the chamber sensitive volume. The value of the threshold energy is strongly dependent on the construction (materials and geometry) of the calibrator. This explains the large difference in efficiency between 90Y and 32P for different types of dose calibrator.

ICMP 2013

DAY 4, TRACK 3

CT DOSE

Paper Number: 0202

A PROCEDURE FOR TRANSFERRING SCAN PROTOCOLS BETWEEN MULTI-SLICE CT SCANNERS IN FOUR STEPS

Isabel Castellano, Daniel Gordon, Laurence King, Edmund McDonagh

The Royal Marsden NHS Foundation Trust, London, UK

AIM

Transferring scan protocols to a new CT scanner is challenging. The aim of this work was to develop a robust procedure for effecting this transfer whilst ensuring optimized patient dose characteristics.

MATERIALS AND METHODS

A four-step procedure was tested on a scanner pair from one manufacturer, and a second scanner pair from different manufacturers. Firstly, a patient dose audit was conducted on the existing scanner using automated dose data collection of patient dose metrics and demographics. Secondly, the tube current modulation (TCM) was characterised on both scanners using uniform Perspex phantoms ranging between 16 and 32 cm in diameter. Thirdly, TCM settings and scan protocols were configured on the new scanner. Finally, a patient dose audit was carried out on the latter.

RESULTS

The procedure did not work well for the first scanner pair. Dose discrepancies of 33, 48 and 67 % were noted for chest scans of small, medium and large subjects. An anthropomorphic chest phantom was used to investigate the causes and reconfigure the scan protocols. The procedure worked well for the second scanner pair for small and medium subjects where doses agreed to within 10 %. However the Perspex phantoms did not fully characterize the TCM performance, leading to discrepancies of 21 % for large subjects.

CONCLUSIONS

A five-step scanner matching procedure which combines patient dose audits, a full TCM characterization, and confirmatory scans of anthropomorphic phantoms, is required in order to ensure that patient dose characteristics are matched across existing and new CT scanners.

Paper Number: 0373

PATIENT-SPECIFIC CALCULATION OF ORGAN DOSES FOR COMPUTED TOMOGRAPHY

Serge Dreuil[1], Aymen Ben Abdennebi[2], Jérémi Bezin[2], Ibrahima Diallo[2], Damien Llanas[2], Tilia Soubbotine[1], Cristina Veres[2]

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Dose evaluation of the CT procedures is an important issue for the determination of the benefit-risk ratio as well as for public health studies. Current methods based on standardized dosimetric indices are neither accurate nor precise and do not take into account the morphological variability of patients. We present a fast and reliable method, currently under implementation at our institute, for a patient-specific calculation of the organ doses.

A range of deformable anthropomorphic numerical phantoms has been developed for the two genders and for various ages, morphologies and examination positions. These phantoms are converted into DICOM images of 3 mm cubic voxels. Dose distribution resulting from standard CT procedures is calculated with a GPU-based, Monte Carlo simulation software (ImpactMC, CT Imaging GmbH, Erlangen). Two CT scanners are considered: a Siemens Sensation 64 whose X-ray beam model is embedded with the software and our institute's Siemens Sensation Open 40. The beam model of the latter has been established experimentally by a method based on HVL measurements (Turner et al, Med. Phys. 38, 2009) and validated by comparison with CTDI measurements in a cylindrical phantom and with point dose measurements in an anthropomorphic physical phantom.

Dose-volume histograms of each of the numerical phantom organs will be computed and compared to those obtained with classical dose evaluation tools such as CTDosimetry, ImpactDose or CT-Expo.

Paper Number: 0263

CT AUTOMATIC EXPOSURE CONTROL OPTIMISATION IN PET-CT

Gareth Iball, Garry McDermott, Michael Waller

Leeds Teaching Hospitals NHS Trust, Leeds, West Yorkshire, UK

Modern PET-CT scanners are equipped with CT automatic exposure control (AEC) systems which are used to adjust tube current according to patient size. When optimising clinical scan protocols the set up of the CT AEC system must itself be optimised.

CT protocol optimisation was undertaken on PET-CT systems from two manufacturers. Following reports of sub-optimal image quality on Scanner A retrospective optimisation work generated weight-based scan protocols incorporating rotational tube current modulation. On Scanner B, prospective protocol optimisation was undertaken using scans of an anthropomorphic phantom. A subsequent routine audit of patient dose and image quality revealed significant differences between the two systems, especially for small patients.

A direct comparison of the AEC systems was made by scanning the anthropomorphic phantom on the clinical protocols and following adjustments to the AEC set-up. The tube current variation along the phantom was established and used alongside the displayed dose metrics to establish revised scan protocols, with improved AEC set-up, on Scanner A.

The initial optimisation on Scanner B reduced doses by approximately 50% from the manufacturer's standard. Routine dose audit showed that doses on Scanner A were up to three times higher, whilst image noise was 50% lower, than on Scanner B. A repeat dose audit following protocol changes on Scanner A showed dose reductions of approximately 30% and broadly consistent values of dose and image quality on the two scanners.

A range of optimisation methods have been used to harmonise dose and image quality on PET-CT scanners from different manufacturers.

Paper Number: **0147**

A PRACTICAL STUDY OF CT NUMBER ACCURACY AND APPLICATIONSA PRACTICAL STUDY OF CT NUMBER ACCURACY AND APPLICATIONS

Julian Liu, Steve Morgan, Anne Miller, Paul Colley, John Lutkin

Royal Sussex County Hospital, Brighton, UK

The accuracy of CT numbers is a key factor for some clinical diagnosis situations and in radiotherapy planning. Having developed an accurate and automatic software package, we designed experiments for investigating the factors affecting the accuracy of CT numbers.

The CTP404 Catphan 600 insert was scanned twelve times each week for ten months using a Siemens Biography to determine CT number baselines and tolerance values, and to investigate the influence of phantom temperature on CT number. The same Catphan was scanned using several scanners from different manufacturers to compare the reported CT numbers. A set of half-circle scans with 80 different X-ray tube starting angles (4.5˚ interval) were acquired to analyse the variation in CT number that arose.

The software improved the accuracy of CT number analysis and allowed a new set of baselines with tighter tolerances to be established. Phantom temperature was shown to have a significant and reproducible effect on CT number and it is therefore recommended that this variable is controlled in routine testing. Where diagnostic tests are dependent on accurate CT number reporting, it is proposed that radiologists use a conversion table in order to correct for any differences between scanners. For half-circle scans, the starting angle was shown to affect the CT numbers in some regions, which could have implications for dose calculation accuracy in radiotherapy planning.

Paper Number: 0376

CHARACTERIZATION OF THE OPTICALLY STIMULATED LUMINESCENCE NANODOT FOR CT DOSIMETRY

M. Yusuf[1], H. Natto[1], F. Nadwi[1], N. Alothmany[1], D. Alothmany[1], S. Natto1, N. I. Molla[1], A. Kinsara[1], N. Mail2, A. Saoudi[2]

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PURPOSE
To characterize dose response of optically stimulated luminescence (OSL) nanoDot detector (OSLD) for computed tomography (CT) dosimetry and compare it with various ionization chambers responses.

METHODS
The relative response of OSLD to scan length from 5cm up to 40 cm were performed and compared with three PTW ionization chambers; Semiflex 0.125 cm3, Farmer 0.6 cm3 and Pencil 3.14 cm3. The effect of OSLDs orientation on CT dosimetry was studied in a cylindrical water phantom (20cm diameter and 46cm length) by rotating the OSLDs around Z-axis and X-Y-axis.

RESULTS
All detectors showed the same trend of dose increase when scan-length increases from 5cm to 40 cm due to the increase of the scatter component. The OSLDs and pencil ion chamber response showed an under estimation of dose at 5cm scan length of respectively 59% and 54% compared to both Semiflex and Farmer chamber which was 65%. The angular response of the OSLDs did not exceed 3.6% variation for all energies 80-120 kVp at doses higher than 20 mGy but could varies up-to ±18.6% for small doses below 10mGy.

CONCLUSIONS
The OSLDs under estimate the dose for small scan-length due mainly to the higher sensitivity of the detector for lower energies component generated by larger scanning volume. This is different from the under estimation of relative dose response of the pencil ion chamber caused mainly by its larger volume. The OSLDs showed almost no orientation dependence in CT dosimetry when statistical noise of the reader is reduced by increasing scan dose.

ICMP 2013

DAY 4, TRACK 4

IOP MEDICAL PHYSICS GROUP

ICMP 2013

DAY 4, TRACK 4

PROTECTION IN THE PET ENVIRONMENT

Invited Speaker

RADIATION PROTECTION IN PET/CT

Mrs Debbie Peet

Head of Radiation Protection, The Royal Surrey County Hospital NHS Foundation Trust, Egerton Road, Guildford, Surrey, GU2 7XX

A brief description of PET/CT scanning will be given, highlighting the particular challenges in terms of radiation exposure of staff and members of the public.

Radiation protection within facilities will be described with consideration of different room layouts and potential challenging situations.

The radiation protection measures that might be used in routine operation will be described. Staff doses that might result from different facilities will be discussed.

Paper Number: 0318

MODIFYING TECHNIQUES TO REDUCE STAFF DOSES IN PET/CT: HOW EFFECTIVE ARE THEY?

Abdalla Al-Haj[1], Aida Lobriguito[2]

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PET/CT procedures are being made available in large medical centers in Saudi Arabia due to the increasing demand for patient cancer therapy and management. Adult and pediatric patients for PET/CT increases every year by almost two-fold. Doses to staff have been determined using different methodologies and efforts to reduce staff doses have been recommended. Initial study showed that the estimated staff dose per procedure for the wrist is the highest and could be about 9.6 μSv. The whole body doses during injection and imaging were found to be about 50% of the wrist dose. Staff doses during preparation, injection and patient positioning could vary by a factor of 3 to 7. This study aims to determine how effective are the different modified techniques in reducing staff doses from Fluorine-FDG. Techniques to be used to reduce staff whole body doses are the following: rotation of staff, use of 3-way stopcock extension line during injection, use of syringe carrying box with lead shielding for Fluorine and use of a transfer station for Fluorine-FDG from preparation bench to injection area when giving instructions are being carried out. Staff doses are measured using a survey meter before and after modifying the techniques. Standard protocol for staff protection will be recommended.

Paper Number: 0204

TRENDS IN FREQUENCIES AND COLLECTIVE DOSES FROM NUCLEAR MEDICINE IN BULGARIA

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Since 2007 the National Centre of Radiobiology and Radiation Protection is collecting annually information about frequencies and administered activities of radiopharmaceuticals used for diagnostic and therapeutic nuclear medicine procedures. Standardized questionnaire was developed and sent electronically to all nuclear medicine departments in the country. The questionnaire was structured in several sections, aimed to study available nuclear medicine equipment, nuclear medicine diagnostic examinations of adults (number and administered activities); nuclear medicine diagnostic examinations of children (number and administered activities); therapeutic procedures (number and administered activities). The total number of NM examinations increased slightly, from- 19175 in 2007 to 21809 in 2012. Tumor imaging studies increased more than 7 times, mainly due to the introduction of PET in 2010. The major contributors to the frequencies are examinations of musculoskeletal system (59.5% in 2012), the endocrine system (13.4%), tumor imaging (13.9%), lung perfusion (6.7%), urinary tract (4%). Individual effective dose varied between less than 1 mSv (hematological studies) to above 10 mSv, with relatively highest effective doses for imaging of thyroid metastasis after ablation of thyroid with I-131, ventriculography with Tc-99m, tumors diagnostics with I-123 MIBG, myocardial perfusion with TC-99m MIBI. Bone scintigraphy has the largest contribution of 50.0% to the annual collective dose in 2012, followed by PET imaging of tumors, contributing to 15% of total frequency and 25% of collective dose.

Paper Number: 0133

DEMONSTRATE OCCUPATIONAL RADIATION PROTECTION AT RADIATION THERAPY OF B.P.KOIRALA MEMORIAL CANCER HOSPITAL (BPKMCH) IN BHARATPUR, NEPAL

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BACKGROUND

The BPKMCH is the nucleus of therapeutic radiology in Nepal with machines like tele- cobalt, two linear accelerators with photons and electrons is providing safe and effective treatment of cancer patients since 2002. Patients received conventional 2D, conformal 3D and few IMRT radiotherapy and High Dose Rate brachytherapy . 600C/D Clinac was upgraded with IMRT in 2012.

OBJECTIVES

Demonstrate leakage measurements dose rate during, OFF position of Cobalt unit , Ir-192 HDR machine near head, and in control console area of machine during beam on conditions. Survey the control console area of both the linear accelerators.

Analyze the (TLD) personnel badge cumulative dose of five years.

MATERIALS AND METHODS

A calibrated Aloka survey meter measured the radiation level at different points of tele -Cobalt machine and HDR Ir-192 machine during OFF position and during machine source ON/ photon beam on conditions. TLD badges available for personnel monitoring and MPD for workers is 20 milli Seivert/year.

RESULTS

The leakage dose rate on head of cobalt during OFF condition at 5 cm and at 100 cm will be presented graphically. The annual survey 0.30 milli Seivert in cobalt machine. The mean occupational dose from personnel monitoring is 0.21 milliSeivert /year. The quantitative risk due to exposure and of secondary radiation levels of high energy 20 MV photon . Ir-192 source survey and transport index value provided by RSO .

CONCLUSION

The facility is safe for workers, patients and public but strict and sensible working procedure is to be followed.

ICMP 2013

YOUNG INVESTIGATORS

Paper Number: 0004

INVESTIGATION OF THE ACCURACY OF AN ANTHROPOMORPHIC PRESAGE® DOSIMETER IN THE DOSIMETRIC EVALUATION OF BREAST IMRT

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PURPOSE
This work presents an investigation into the PRESAGE® dosimeter with optical CT scanner as a 3D dosimetry system. An anthropomorphic PRESAGE® phantom was created from a commercially available breast phantom.

METHODS
A five field IMRT plan was generated in a commercially available treatment planning system and delivered to this phantom. Comparisons were performed between the Pinnacle3 treatment planning system calculated dose distribution, PRESAGE® dosimeter and GAFCHROMIC® EBT2 film. Dose volume histograms (DVHs), gamma maps, isodose distributions and line profiles were used to evaluate the agreement.

RESULTS
Edge artifacts were observed on the optical CT reconstruction, from the surface to approximately 8 mm depth. These artifacts resulted in dose differences between Pinnacle3 and PRESAGE® of 5% at the surface and decreased with increasing depth in the phantom. Gamma map comparisons showed that all three distributions agreed with greater than 95% of comparison points passing the ±7% of ±3 mm criterion. Line profile comparisons between all three independent measurements yielded agreement of 98% within the central 80% of the field width. The isodose line distribution comparisons between PRESAGE® and Pinnacle3 exhibited agreement to within 4%.

CONCLUSION
The breast IMRT plan studied, Pinnacle3 dose calculation was found to agree with both PRESAGE® and GAFCHROMIC® EBT2 film measurement to within 7%, 3 mm gamma criteria.

Paper Number: **0044**

THE DOSIMETRIC EFFECT OF JAW TRACKING IN VOLUME MODULATED ARC THERAPY (VMAT)

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The purpose of this study is to investigate how much the jaw tracking method in VMAT technique can reduce the dose to normal tissues. The interleaf leakage with and without jaw tracking in sliding gap pattern of a TrueBeam machine was measured by using Gafchromic EBT film. The treatment plans of head & neck, lung and prostate cancers (ten patients for each) were performed with and without jaw tracking using Eclipse v.10.0. The volume of integral dose was determined by subtraction of PTV from Body. From DVH, the integral doses of V5 and V10 of that volume were determined for calculating the dose reduction by jaw tracking. The patient specific QA of every plan was done by using X- plane diode array (Delta 4) with the gamma index criteria of 3%, 3 mm. The interleaf leakage with jaw tracking was 37.5% less than without jaw tracking. The integral dose reduction of V5 and V10 (V5/V10) were 2.69% ± 0.70 / 2.40% ± 1.02 for head & neck, 0.98% ± 1.10 / 0.11% ± 2.11 for lung, and 0.56% ± 0.68/ -1.37 ± 2.10 for prostate. The patient specific QA for every plan shows the percent pass with more than 95%. The results indicate that the jaw tracking is more efficient in the reduction of low dose in normal tissue with irregular shape tumor, such as head & neck cancer.

Paper Number: 0088

MULTICHANNEL FILM DOSIMETRY USING EBT3 GAFCHROMIC FILM AND MATLAB

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The use of film dosimetry in radiotherapy provides significantly higher resolution than electronic arrays. EBT3 Gafchromic film allows for one-scan analysis by combining radiation dosimetry verification and calibration in a single scan. This is a new protocol which only requires the patient film, a reference region and an unexposed region. Calibration and readout uses 3 colour channels and the protocol eliminates error sources such as interscan variability, enabling errors to be significantly reduced. The techniques have been described by Micke et al [1,2].

A rational fitting function is used to model calibration curves for film response in each colour channel. The reference region and unexposed region are used to rescale the rational fitting function for each patient film. The three channels are used to provide an optimum radiation dose value on a pixel by pixel basis.

This is implemented at the Royal Free Hospital Radiotherapy Department using Matlab programming language and an Epson V700 scanner. Optimised radiation dose maps can be created using the three channel technique with gamma analysis performed on a range of techniques including IMRT, VMAT and comparisons with Dosimetry Check software.

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Paper Number: 0112

WHEELCHAIR TRANSPORT OCCUPANT RESTRAINT SYSTEMS FOR CUSTOM CONTOURED SEATING

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INTRODUCTION

Specialist seating systems are designed and built for posture control, often with little or no consideration to transportation issues, leaving patients dangerously at risk when in transportation.

Although there are a number of ISO (International Organization for Standardisation) standards relating to wheelchairs in transportation, these are market driven, voluntary guidelines and as such there is no legally binding statute. This means that people are being transported in many different ways, and not always safely.

Two types of occupant restraint systems for use with custom contoured seating have been compared. The results show the choice of occupant restraint used is critical to patient safety.

METHOD

Limitations in current practices by transport companies and carers of patients with special seating systems have been recorded.

The constraints imposed by the intended purpose of the wheelchair seating that is provided have been considered.

Two sled tests were conducted, comparing a vehicle mounted occupant restraint system to a wheelchair integrated occupant restraint system.

RESULTS

The kinematic and video data from the sled tests confirmed that a wheelchair integrated occupant restraint system is suited for crashworthy special seating systems for use in motor vehicles. However the wrong choice of occupant restraint can result in extremely unsafe situations occurring.

DISCUSSION

This project highlights the need for wheelchair prescribers to take the initiative in transport related matters. Further work is needed to develop a range of hardware solutions to meet patient needs, based on the constraints imposed by their circumstances.

Paper Number: 0127

EVALUATION OF PATIENT SET-UP ERRORS USING PORTAL IMAGING AND THEIR IMPACT ON THE GEUD CALCULATION AND ON PREDICTIVE MODELS TCP AND NTCP IN CASE OF NASOPHARYNX CANCER

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BACKGROUND AND PURPOSE

In order to evaluate the patients set-up errors and study their impact on the calculation of generalized Equivalent Uniform Dose (gEUD), and on predictive models like Tumor Control Probability (TCP) and Normal Tissue Complication Probability (NTCP) we used electronic portal imaging device (PID).

PATIENTS AND METHODS

Twenty patients treated for nasopharynx with non-coplanar beams were enrolled. Systematic and random errors were quantified. Plan evaluation for target volume and organs at risk (OARs) coverage were assessed using calculation of gEUD, TCP and NTCP. For this purpose, homemade software was developed and used.

RESULTS

The standard deviations (1SDs) of the systematic set-up errors ($\sum$ = 0.63 mm) and random set-up errors (σ = 3.75 mm) were calculated and gave the following results: 0.42 and 0.79 respectively. Thus a (PRV)- margin of 3 mm was defined around the OARs. The gEUD, TCP and NTCP calculations obtained without and with position error show increased values for tumor where ΔgEUD(Tumor) = 3.56% Gy (p = 0.00373 vs 0.0562) and a ΔTCP = 3.5%. The toxicity of different OARs was quantified using gEUD and NTCP. The values of ΔgEUD(OARs) vary from 0.04 % for optic nerf to 2.32 % for optic Chiasma and the corresponding ΔNTCP vary from 0.05 % to 0.53 % respectively.

CONCLUSION

Evaluation of set up errors using PID has an impact on the definition of PRV-margin and on predictive models calculations. The homemade software developed can be used successfully to evaluate and optimize treatment.

Paper Number: 0129

EVALUATION OF VOLUMETRIC MODULATED ARC THERAPY (RAPID ARC) AND INTENSITY RADIATION THERAPY (IMRT) USING THE CONCEPT OF GENERALIZED EQUIVALENT UNIFORM DOSE (GEUD) FOR HEAD AND NECK CAVITY MALIGNANCIES

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BACKGROUND AND PURPOSE

The aim of this study is to evaluate different treatment plans established in intensity modulated radiotherapy (IMRT) and in a volumetric modulated arctherapy RapidArc (RA) using the concept of the generalized Equivalent Uniform Dose (gEUD).

PATIENTS AND METHODS

Twenty-one patients treated in IMRT and thirteen others in RA. All of them presenting tumors of head and neck were studied through the analysis and the evaluation of their treatment plans. A calculation of gEUD and tumor control probability TCP was established by homemade software.

RESULTS

The evaluation of the treatment plans established in IMRT and in RA gave the following results in terms of the handled various target volumes in IMRT and in RA: The relative discrepancy on the mean doses received on the PTVs which varies from 1.15 % to 2.04 % is in favor of RA. The correlation coefficient R between the values of gEUD and the TCPs reaches 0.9 indicating that these two parameters vary in the same way. An increase of ΔTCP = 5.8 % was obtained for the tumor with RA treatment.

The results obtained for the different OARs shows a decreased doses values in case of RA, where ΔgEUD vary from 1.69 % for spinal cord (p = 0.70) to 12.94 % for larynx (p = 0.035).

CONCLUSION

The evaluation of these two treatment technique showed the superiority of RA thanks to the concept of the gEUD, with higher dose values at the tumor levels and less doses at the OARs compared with IMRT.

Paper Number: **0174**

A SYSTEM TO AID THE MAPPING OF PRE-SURGICAL MARGINS IN BASAL CELL CARCINOMA USING OPTICAL COHERENCE TOMOGRAPHY.

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Basal cell carcinoma (BCC) is the most common form of skin cancer, and represents a significant global health burden. The main treatment is currently surgical excision, either via standard excision or Mohs micrographic surgery (MMS). Standard excision relies on a visual assessment of the tumour border, often resulting in removal of a wide margin of healthy tissue. MMS uses histological analysis to confirm excision of the full tumour volume, which is expensive and time-consuming, and is thus generally reserved for large or recurrent BCCs.

Optical coherence tomography (OCT) is a high-resolution optical imaging modality, which recent research suggests may be used to define histological features of BCC and delineate tumour margins. This paper presents a novel tool that may be used to non-invasively map the margins of basal cell carcinoma (BCC) before surgery, thus reducing the number of excision stages required in MMS, or improving the accuracy of standard excision. The tool consists of a commercial OCT probe that has been modified to incorporate motion tracking. This enables the clinician to capture the coordinates of the tumour margin to a PC and register these with a clinical image of the lesion. The potential to incorporate a module that can physically mark the margin on the skin in real-time is also explored.

Paper Number: 0186

OPTIMISING A METHOD FOR ABSOLUTE AND RELATIVE SINGLE-CHANNEL DOSIMETRY USING GAFCHROMIC EBT2 FILM FOR CYBERKNIFE STEREOTACTIC RADIOTHERAPY TREATMENT PLAN VERIFICATION

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INTRODUCTION

CyberKnife is able to precisely deliver many small radiation fields in order to produce highly conformal dose distributions which allow dose escalation whilst sparing nearby healthy tissues. These steep dose gradients require high resolution dosimetry systems in order to achieve precise verification of the planned dose distribution. Multi-channel software is commercially available and has been shown to result in accurate absolute dose measurements. However, existing single-channel software is more easily available.

METHODS

Systematically varying one parameter at a time, we optimised a Gafchromic EBT2 (ISP, Wayne, NJ) film calibration and scanning method for treatment plan verification using single-channel dosimetry in both absolute and relative modes. The film response curve was obtained irradiating the EBT2 film with a 6 MV photon beam produced by a CyberKnife (Accuray Inc, Sunnyvale, CA, USA). The SNC Patient (Sun Nuclear, Florida, USA) software was used and film was scanned using an Epson V750 Pro flatbed RGB scanner.

RESULTS

Our recommendations are to use seven dose levels within the 0 to 1000 cGy dose range; maintain the film dimensions between the clinical and the calibration films; place the film at the centre of the scan field but without the use of a mask around the film; perform three warm-up scans; and avoid gaps between the scanner glass and the film.

CONCLUSIONS

This method proved the best solution with the highest accuracy achieved for relative dosimetry with single channel. However, errors in absolute dosimetry remained higher than those in relative mode using this single-channel method.

Paper Number: 0213

AN AUTOMATED METHOD FOR THE QA OF LINAC PHOTON ENERGY THROUGH COMPUTER-DRIVEN EPID IMAGE ANALYSIS OF PHYSICALLY WEDGED BEAM PROFILES.

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Measurement of parameters of interest in routine linac QA using EPID image analysis is desirable as it establishes a framework through which automated QA can be performed, significantly reducing clinical time required for QA activities. We present a technique for quantifying linac photon beam energy based on fitting wedge profiles measured through EPID imaging. Measurements were taken at a variety of energies on an Elekta Synergy platform linac equipped with an Elekta iViewGT EPID panel (Elekta Ltd, Crawley, UK) and a PTW plotting tank (PTW, Freiburg, Germany) was used to measure PDD at 10cm (PDD10). Images of physically wedged fields were acquired using the EPID for all energies. Quadratic fits were applied to the extracted wedge profiles and the second-order coefficients were taken as a metric of energy. The relation between this metric and PDD10 was investigated and was found to be highly linear (R2 = 0.98). Repeatability measurements indicated a variability of ±0.37%. The linear relation to energy combined with this variability yielded an uncertainty that was negligible compared to that associated water-tank PDD10 (±0.3%). Therefore, the new method is at least as accurate as the gold-standard water-tank method. The experimental method was reproduced using an identical linac within a matched fleet; the results for both linacs were found to agree down to low energies beyond the local QA action thresholds. We conclude that the new method allows automated measurement of linac photon beam energy to be performed in a significantly shorter time than current local practices require.

Paper Number: 0238

VOLUMETRIC MODULATED ARC THERAPY VS. CONVENTIONAL THERAPY FOR THE TREATMENT OF MID-OESOPHAGEAL CANCER

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BACKGROUND

The purpose of this study was to compare the planning target volume (PTV) coverage and sparing to organs at risk (OARs) achieved when using volumetric modulated arc therapy (VMAT) RapidArcTM compared to conventional treatment for mid-oesophageal tumours with EclipseTM AAA algorithm (Varian Systems Ltd.)

METHOD

Ten patients with mid-oesophageal cancer were treated with conventional radiotherapy. Dose to OARs, such as the spinal cord, heart and lungs were determined and compared to those of ten VMAT plans. The dose constraints for the VMAT plans were complied from a systematic literature review.

RESULTS

The VMAT plans delivered a significantly lower dose to the spinal cord and heart than the conventional plans. The lung dose for V5Gy, V20Gy and mean lung dose for VMAT were found to be; 63.8% (SD=9.5), 13.6% (SD 5.1) and 10.4Gy (SD=2.1) as opposed to 62.4% (SD=17.8), 18.9% (SD=5.9) and 12.4Gy (SD=3.4) for conventional. The PTV coverage for VMAT was found to be more conformal with a RTOG conformity index (CI) [1] of 1.1 compared to 1.51 for conventional.

CONCLUSION

The results demonstrate that using VMAT instead of conventional radiotherapy offers improvements in OAR sparing without detriment to PTV coverage. While both methods result in conformal plans, the VMAT plans were found to conform more ideally to the target volume.

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Paper Number: 0287

PATIENT-SPECIFIC CT DOSE DETERMINATION FROM CT IMAGES

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PURPOSE
To establish a clinically applicable Monte Carlo (MC)-based dosimetry package for patient-specific CT dose determinations using patient CT images.

METHODS
The CT source spectrum was simulated based on half-value layer measurements. Analytical calculations along with the measured flux distribution were used to estimate the bowtie-filter geometry. Relative source output at different points in a cylindrical phantom was measured and compared with MC simulations to verify the MC model. An mAs-to-dose conversion factor was determined with in-air measurements using an Exradin A1SL ionization chamber. Longitudinal dose profiles were measured with TLDs and compared with the MC-simulated dose profiles to verify the mAs-to-dose conversion factor. The MC-based technique was evaluated in a clinical study using CT colonoscopy and normal abdomen/pelvis CT images, and compared with current CT dosimetry practices.

RESULTS
Root-mean-square deviation between the relative source output measurements and simulations was 2.18%. The difference between the TLD-measured and MC-simulated dose was less than 3.8% within the beam width. The current CT dosimetry methods determined that the two patients received equal dose, whereas the MC-calculated mean doses from the abdomen/pelvis scan were higher than those from the CT colonoscopy by 7.5%, 6.5% and 12.8% for bony anatomy, left kidney, and right kidney, respectively.

CONCLUSION
A clinically applicable, MC-based patient-specific CT dose calculation tool based on patient CT images was established and verified. The clinic study shows this method is an improvement on current CT dosimetry.

Paper Number: 0288

CLINICAL IMPROVEMENT IN STEP AND SHOOT IMRT DELIVERY ACCURACY ON VARIAN TRUEBEAMTM

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PURPOSE
The dose delivery accuracy of 30 clinical step and shoot intensity modulated radiation therapy (IMRT) plans was investigated using the single integrated MLC controller of the Varian Truebeam linear accelerator (linac) and compared with the dose delivery accuracy on a previous generation Varian 2100CD C-Series linac.

METHODS AND MATERIALS
10 prostate, 10 prostate and pelvic node and 10 head and neck cases were investigated in this study. Dose delivery accuracy on each linac was assessed using farmer ionisation chamber point dose measurements, 2D planar ionisation chamber array measurements and the corresponding Varian dynamic log files. Absolute point dose measurements, fluence delivery accuracy, leaf position accuracy and the overshoot effect were assessed for each plan.

RESULTS
Absolute point dose measurements improved by 1.5% on the Truebeam compared to the 2100CD linac. No improvement in fluence delivery accuracy between the linacs, at a gamma criterion of 3%/3mm was detected using the 2D ionisation chamber array or the Varian log files. However, log files revealed improved fluence delivery at 1%/1mm criterion on the Truebeam (99.87; 99.78-99.99) (median; IQR) compared to the 2100CD linac (97.87; 91.93-99.49). Log files also revealed reduced root mean square leaf position errors on the Truebeam (0.023±0.015mm, mean±1SD) compared to the 2100CD linacs (0.239±0.066mm). The overshoot effect, characterised on the 2100CD linac, was not measured on the Truebeam.

CONCLUSION
The integrated MLC controller on the Varian Truebeam improves clinical treatment delivery accuracy of step and shoots IMRT fields compared to delivery on a Varian C-series linac.

Paper Number: **0356**

ASSESSING THE USE OF IONIZATION CHAMBERS FOR FLATTENING-FILTER-FREE BEAM CHARACTERIZATION USING MEASUREMENT AND MONTE CARLO METHODS

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Ionization chambers exhibit increased ion recombination in radiation beams with higher dose-per-pulse. This poses a potential problem for dosimetry of high-dose-rate flattening-filter-free (FFF) linear accelerators. Kry et al. (2012) showed that the two-voltage determination of Pion used in TG-51 is sufficient to correct for recombination in Farmer-type chambers, but small-volume chambers typically used for commissioning measurements have not been investigated.

Saturation curves were obtained for various dose-per-pulse beams using a Varian TrueBeamTM accelerator. Both digital and analog electrometers were used, and were specially fitted to allow varying bias voltages. Chambers from multiple vendors and ranging in volume from scanning to Farmer-type chambers showed very good agreement between Pion values defined by the two-voltage technique and the more rigorously defined values obtained from Jaffe plots. For example, Pion values for an Exradin A1SL (0.053 cm3) agreed within 0.2%.

Additionally, a Monte Carlo model of the accelerator was developed using EGSnrc and phase space files provided by Varian. Percent-depth-dose curves and profiles at several depths were compared to commissioning data. It was determined that EGSnrc may not be ideally suited for TrueBeamTM modeling because of the geometry simplifications required by EGSnrc and the inflexibility of phase space sources. However, simulated and measured results agreed fairly well considering these limitations.

Ionization chambers have been shown to be reliable for FFF dose determination and beam characterization measurements. Because these measurements affect every patient treated on a given machine, confidence in their accuracy is crucial to delivering high quality patient care.

Paper Number: 0182

OPTIMAL COUCH DESIGN PROFILE FOR PROTON GANTRY RADIOTHERAPY

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At Paul Scherrer institute it has been developed an isocentric proton gantry, which allows treatment from any direction. In order to exploit the full capabilities of this technique a suitable patient treatment couch has to be designed and developed.

The aim of this work is to investigate the optimal couch profile in order to minimize the dead angles and to reduce the impact of the couch material on the beam. The couch structure is designed as a carbon - foam sandwich; to show the technical feasibility, a preliminary study of the stiffness of two different profiles (rectangular and hemispheric) as a function of the thickness and the size of the different carbon layers has been done.

We performed an analysis of the variation of the water equivalent range (WER) while moving along the couch profile. Near the couch edges a WER difference up to 26mm for the rectangular and 4mm for the hemispheric has been found out.

The dosimetric impacts of the couch profile for the patients' treatments have been evaluated for 4 clinical cases of paraspinal tumors in supine position. We considered for different single beam directions going through the couch (in the range ±40° from the PA direction) and for an IMPT plan, the dose distribution differences between the nominal dose distributions and the one calculated assuming a patient misalignment up to 4 mm along the horizontal and the vertical direction. Those differences were larger (75%) for the rectangular profile than for the hemispheric (40%).

Paper Number: 0304

COMPARISON OF TARGETING ACCURACY FOR TREATMENT LOCALIZATION WITH DIFFERENT CT IMAGES IN MOVING TARGET OF THORAX REGION.

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The purpose of this study was to compare the target localization accuracy using 4 different types of reference image reconstructions. A Programmable Respiratory Motion Phantom was enrolled in this study with the respiratory rate, breathing amplitude, and tumor movement range in SI direction of 15 bpm, 1.0 cm, and 2.0 cm, respectively. Free breath (FB) and 10 phases of the 4DCT were performed. Average (AVG), Mid Position (MidP), and Maximum Intensity Projection (MIP) were generated. The FB-CBCT at a TrueBeam machine were acquired. The registration based on DICOM origin of each reference image to the CBCT was done. The targeting accuracies were analyzed by using matching Index (MI) of 3D tumor volume from each reference image with CBCT's and tumor matching. The image quality and tumor shape of the reference were also compared with the CBCT using a 5-point grading scale. Mean error of target position was significant only in SI direction with the maximum of 3.11 ± 0.65 mm ($p < 0.01$) for MidP and not significant for the rest. AVG and FB show MI value closer to 1 with 0.95 and 0.93 respectively than the other two images (MI = 0.63 and 0.77). The 5-point grading scale illustrates the highest mean scores of both image quality (3.8 ± 0.63) and tumor shape (3.9 ± 0.73) for the AVG. From this study, the AVG is preferred to be the reference image in moving target. Patient respiration may effect on-line CBCT. Further study in patient will be achieved later.

ICMP 2013

AWARDS

QUANTITATIVE SUSCEPTIBILITY MAPPING (QSM) IN THE HUMAN BRAIN - A NEW MRI CONTRAST

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Magnetic susceptibility is the physical quantity that describes the interaction of a substance with an applied magnetic field and, thus, may be regarded as one of the most fundamental properties in the field of magnetic resonance (MR). Ever since the early days of magnetic resonance imaging (MRI) there has existed a strong interest in tomographic quantification of the magnetic susceptibility—this quantity bears the potential to improve the characterization of brain lesions and to sensitively assess paramagnetic tissue iron, a promising biomarker to objectively evaluate the status of several neurodegenerative diseases. Nevertheless, magnetic susceptibility is one of the few physical properties that have been inaccessible by in vivo MRI until very recently.

The talk will introduce a set of techniques that enable quantification of magnetic susceptibility in human brain with MRI. The method, also referred to as quantitative susceptibility mapping (QSM), makes use of the phase of the complex-valued MR signal which reflects the magnetic field perturbation induced by the brain's magnetic susceptibility distribution and has been hitherto often disregarded.

The availability of QSM represents an important step toward more specific imaging of tissue properties, directing ipso facto many future research applications.

EMITEL WEB MANAGEMENT SYSTEM – KEEPING UP WITH THE LATEST TECHNOLOGY STANDARDS

Dr. Magdalena Stoeva

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EMITEL (European Medical Imaging Technology e-Encyclopaedia for Lifelong Learning) is the world's leading resource for reference information in the fields of Medical Engineering & Physics and related disciplines.

EMITEL runs on a dedicated on-line platform developed to fit the strong requirements of its dynamic environment. The wide application, the extensive usage and the increased compatibility requirements over different users' platforms served as basics to start the upgrade of the management system to the latest technology standards.

Our goal – bring EMITEL closer to the users, enhance the online environment and optimize the document management process. Results and Discussion: The EMITEL administration and content management system have been reworked to meet the HTML5 standards. The on-line engine and management system have been upgraded to the latest .NET & MS SQL technology.

An unique reference environment has been created to manage and control EMITEL web resources. The future steps in this upgrade involve migrating EMITEL to a cloud based environment.

ICMP 2013

POSTER SESSION

Paper Number: 0327

'ONE STOP CT QA'; POSSIBLE WITH THE CELT PHANTOM.

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Physicists have, for many years, been using a range of standardised test phantoms to assist them in monitoring and comparing x-ray CT scanners.

As technological changes have been introduced into CT scanners, the traditional phantoms have not kept pace with these changes and, it could be argued, are no longer capable of fully evaluating the scanner. Additionally, there are pressures on both the personnel performing the quality assurance programme and also on the clinical users. This is due to increasing numbers of scanners to assess, increased patient referral and examination complexity. Therefore, it would be beneficial to streamline the required testing.

The CelT phantom has been developed to allow "One Stop QA" of CT scanners. As such it is possible to use this single phantom to carry out all of the tests required on a routine basis (1). This offers significant savings in test time as only one simple phantom set-up is required. In addition, the elliptical shape of the phantom allows more clinically relevant measurements to be performed. A further benefit of a single phantom is that remote, automated analysis of results is easier.

REFERENCES

(1) IPEM Report 91 'Recommended Standards for the Routine Performance Testing of Diagnostic X-ray Imaging Systems' IPEM, 2005.

Paper Number: 0306

"EVOLUTION OF COMPLEX IMRT PLANNING FOR HEAD AND NECK CANCERS OVER SIX YEARS TO COMBAT ORGAN AT RISK TOXICITY"

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Head and Neck Cancers are very complex to treat using Radiotherapy. This results from close proximity of tumour tissue to organ-at-risk (OAR) tissues and the extension of nodal regions within the head and neck region. In 2010 the Quantitative Analyses of Normal Tissue Effects in the Clinic (QUANTEC) were published to address the problem of reducing toxicity of OARs. The challenges for radiotherapy physicists are optimisation of the planning of radiation treatment in line with QUANTEC and verification of the accurate delivery of radiation by the linear accelerator by means of Intensity Modulated Radiotherapy (IMRT).

A study of all IMRT Head and Neck treatment plans created at University Hospital Galway from 2006 was carried out in 2012 with an emphasis on the OARs.The doses to OARs were assessed with consideration given to the proximity to the Planning Target Volumes (PTVs) and any overlap with the PTVs. The treatment sites reviewed were oropharynx, nasopharynx, hypopharynx, base of tongue, floor of mouth and larynx.

Dose Volume histogram (DVH) analysis was performed on this data for parotid dose, brain-stem, spinal cord and optic chiasm for each plan. The planned doses were compared to the Quantec guidelines. Factors preventing parotid sparing were investigated also. All plans were measured at the linac.

Ability to reduce the OAR dose depends on the location and stage of the primary disease. Upgrades to the treatment planning system improving the simulation of radiation deliverable by the linear accelerators had an impact also on the design of IMRT plans.

Paper Number: 0113

IN VIVO DOSIMETRY FOR PELVIC LOCALIZATIONS TREATED BY INTENSITY MODULATED RADIATION THERAPY USING A SIMPLE EPID-BASED BACK-PROJECTION METHOD.

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INTRODUCTION

In vivo dosimetry remains difficult to achieve for some treatment modalities like Intensity Modulated Radiation Therapy (IMRT). In this work, a back-projection technique previously developed for conformal beams(a,b) using the transit signal of an Electronic Portal Imaging Device (EPID) was studied on pelvic modulated fields.

MATERIALS AND METHODS

The model enables to reconstruct the dose in the patient (DREC), on beam central axis. Prior measurements are necessary to define a set of correction factors to transform EPID signal into dose. Several tests were carried out on homogeneous phantom to detect possible effects on the dose reconstruction of various treatment parameters such as delivered dose, field size dependence and patient thickness. Finally, 90 pelvic IMRT plans (422 beams) have been controlled in which, DREC was compared with the dose calculated by our treatment planning system (DTPS).

RESULTS

Considering the 120 beams delivered on the homogeneous phantom, a mean deviation between DREC and DTPS equal to 1±1.8% (1SD) was found. Concerning the 422 in vivo dose reconstructions from modulated beams, the mean deviation between DREC and DTPS was equal to -0.3±2.6% (1SD).

CONCLUSION

These promising results validate this method which can be used as a robust tool in clinical routine to check the delivered dose, especially for IMRT pelvic treatment cases. This study is now extended to others localizations.

aChang et al.(2000)."Relative profile and dose verification of intensity modulated radiation therapy."Int.J.Radiat.Oncol.Biol.Phys.47(1):231-240.

bFrançois et al.(2011)."In vivo dose verification from back projection of a transit dose measurement on the central axis of photon beams."Phys.Med.27(1):1-10.

Paper Number: 0255

IN-VIVO SKIN DOSE MEASUREMENT USING MOSKIN™ DETECTOR DURING BREAST RADIOTHERAPY

Wei Loong Jong[1], Ngie Min Ung[1], Jeannie Hsiu Ding Wong[2], Kwan Hoong Ng[2], Vincent Chee Ee Phua[1], Rozita Abdul Malik[1], Wan Zamaniah Wan Ishak[1], Dean L. Cutajar[3], Anatoly B. Rosenfeld[3], Gwo Fuang Ho[1]

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INTRODUCTION

Determination of skin dose for breast radiotherapy is important to ensure sufficient dose to the treatment volume without excessive skin reaction. Current treatment planning systems are unable to accurately calculate the dose in the build-up region. Actual skin dose can only be achieved through in-vivo skin dosimetry. In this study, a new Metal Oxide Silicon Field Effect Transistor (MOSFET) based detector, MOSkin™ detector was used to measure the patient skin dose during breast radiotherapy on anthropomorphic phantom and real patients. The special feature of the MOSkin™ detector is that the detector's water equivalent thickness (WED) is 0.07 mm, making it a suitable dosimeter for skin dose measurement.

MATERIALS AND METHODS

A treatment plan for breast radiotherapy was generated and delivered on an anthropomorphic phantom with two parallel opposing tangential beam. Two MOSkin™ detectors were placed on the surface of the centre slice within the treatment fields at 3 cm from the border of medial and lateral beams respectively. The measurement was repeated twice. The measurement was then repeated using Gafchromic EBT2 film. Clinical skin dose measurements were also performed on real patients with same setup.

RESULTS AND CONCLUSION

Results from the measurement using the MOSkin™ detector were in good agreement with results from the Gafchromic EBT2 film measurement. The MOSkin™ detector, with its advantages of small in size, ease of use, and able to provide real-time dosimetric information, may be a novel for in-vivo dosimeter for skin dose measurement during breast radiotherapy.

Paper Number: 0036

3D SURFACE IMAGING IN BREAST RECONSTRUCTION: A KNOWLEDGE TRANSFER PROJECT

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There have been rapid developments in hardware and software to support the clinical applications of three-dimensional (3D) surface imaging. Routine clinical applications of stereophotogrammetry include craniofacial and orthognathic surgical planning and outcome monitoring. More recently it has been recognised as a novel tool for breast assessment and a valuable adjunct to breast surgery in preoperative planning, postoperative evaluation and assessment of surgical outcome.

The transfer of innovative research findings into practice is regarded as a strategic priority for HSC RDO (NI) to ensure research outcomes are disseminated and exploited. Funding to carry out a Knowledge Transfer project was awarded to support four partners (University of Ulster, The Belfast Trust, Axis Three Ltd and Cancer Focus) to investigate and develop a Trust based 3D imaging service.

The outcomes of the project were to

To develop 3D image acquisition, reconstruction and handling skills within the Department of Medical Illustration

To increase the knowledge and experience of clinicians (surgeon/breast care nurse) in the application of 3D technologies in breast reconstruction

To develop robust measurement methodologies including assessment of symmetry and temporal change

These were achieved through installation of a 3D breast imaging system, a series of workshops, focus groups and practical demonstrations between the partners. High quality data were acquired from a range of referrals and data analysis was carried out by the clinician and scientists working together. This work has demonstrated the role of the clinical scientist in bringing research findings into the healthcare environment through knowledge transfer.

Paper Number: 0276

3D TEXTURE ANALYSIS OF PULMONARY CTS: DIFFERENTIATION OF MIXTURES OF PATHOLOGICAL PATTERNS IN THE LUNG

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PURPOSE

Many lung pathologies are mixtures of different pathological patterns which are difficult to be differentiated in CT-data. For example, the superimposition of groundglass and emphysema can fake

honeycombing. Whithin this study it is shown that the use of three-dimensional texture analysis may increase the quality of diagnostic findings in pulmonary CTs due to the better differentiation and quantification of pulmonary disease patterns.

MATERIALS

Retrospectively, 15 thorax CT datasets (0.5 mm slice thickness, native) from 12 patients with different lung diseases (COPD, emphysema, interstitial and granulomatose lung disease, smoke-induced lung disease) were independently analyzed by 2 radiologists with profound experience (5 years, 25 years). Further the same records were examined with the texture analysis algorithm 3D-AMFM (Adaptive Multiple Feature Method) , analyzing CT-data via previously trained disease-specific pathological parenchymal textures (normal, groundglass, honeycombing, emphysema, nodular, tree-in-bud).

RESULTS

92 percent of known lung pathologies were clearly identified by 3D-AMFM. 11 out of 15 cases texture analysis delivered relevant additional information: Mixtures of pathologies could unequivocally be

differentiated and confirmed by a second analysis. Mixtures of emphysema and groundglass could be detected in all cases. In 2 cases mixtures of honeycombing and groundglass could be quantified.

CONCLUSIONS

The disadvantage of the method presented is the absence of a ground truth but seems to be capable to be employed in the separation, differentiation and extent of several pathological patterns.

3D texture analysis can support the radiologist in the interpretation and differentiation of mixed pathological parenchymal patterns.

Paper Number: **0027**

3-D TREATMENT PLANNING OF CHEST WALL /BREAST,USING MONOISOCENTRIC TECHNIQUE WITH JUNCTION VERIFICATION

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PURPOSE

The purpose of this study is to describe the monoisocentric technique that is being followed in the department of Radiation Oncology, Shifa International Hospital, in irradiation of chest wall/breast by tangential fields and the supraclavicular area, with junction verification of the AP and the tangetial fields.

METHODS AND MATERIALS

Thirty patients have been treated using the monoisocentric technique in our department. On the basis of this experience, we show the methods for treatment planning and irradiation, and the methodology for making the isocenter and fields. We have precise treatment planning system, Linear Accelerator having asymmetric four collimator jaws, the longitudinal(Y) jaws beam-split at the match line namely the upper and the lower border of the fields, the transverse (X) jaws defined lateral border of the fields.The match line is clinically confirmed with composite port film.

RESULTS

The monoisocentric technique is simple and easy to setup since the same machine's isocentre is used for all treatment fields and no couch movements or patient reposition is required. Another use of monoisocentric technique is a reduction of treatment time. A composite port film, which includes medial and tengential and supraclavicular fields, shows a perfect match line in all cases.

CONCLUSION

Our treatment technique takes full advantage of dual asymmetric jaws to achieve a perfect match-line, necessitates only one isocenter and set-up point. In monoisocentric technique reproducibility of positioning is simple and precise. This setup is technichian friendly and the match-line is perfect without overdose and underdose at the junction.

Paper Number: 0020

A COMPARATIVE STUDY OF FOUR ADVANCED 3D-CONFORMAL RADIATION THERAPY TREATMENT PLANNING TECHNIQUES FOR HEAD AND NECK CANCER

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For the head-and-neck cancer bilateral irradiation, IMRT is the most reported technique as it enables both target dose coverage and organ-at-risk (OAR) sparing. However, during last 20 years 3DCRT techniques have been introduced which are tailored to improve the classic shrinking field technique, as regards both PTV dose conformality and sparing of OAR's, such as parotid glands and spinal cord. In this study, we have tested experimentally in a sample of 13 patients four of these advanced 3DCRT techniques, all using photon beams only and a unique isocentre, namely Bellinzona, Forward-Planned Multisegments, ConPas and field-in-field (FIF) techniques. Statistical analysis of the main dosimetric parameters of PTV and OAR's DVH's, as well as of homogeneity and conformity indexes, has been carried out in order to compare the performance of each technique. The results show that the PTV dose coverage is adequate for all the techniques, with the FPMS techniques providing the highest value for D95%; on the other hand, the best sparing of parotid glands is achieved using the FIF and ConPas techniques, with a mean dose of 26 Gy to parotid glands for a PTV prescription dose of 54 Gy. After taking into account both PTV coverage and parotid sparing, the best global performance has been achieved by the FIF technique with results comparable to IMRT plans. This technique can be proposed as a valid alternative when IMRT equipment is not available or patient is not suitable for IMRT treatment.

Paper Number: 0280

A COMPARISON OF CONVENTIONAL AND CONTEMPORARY DOSIMETRYFOR A BRACHYTHERAPY COHORT OF 68 APBI PATIENTS

Vasiliki Peppa, Kyveli Zourari, Eleftherios Pappas, Evaggelos Pantelis, Panagiotis Papagiannis

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Conventional brachytherapy treatment planning dosimetry, albeit robust and universally employed, relies on source specific data pre-calculated in a standard homogeneous water geometry. Contemporary treatment planning systems (TPS) are introduced to account for patient-specific radiation scatter conditions and the radiological differences of tissues from water, based on information available through patient imaging. Corrections of dose prescription might be necessary to conform to the accuracy standards that new TPS convey and preserve the global uniformity of current clinical dosimetry practice.

Since new TPS will, at best, achieve accuracy equivalent to Monte Carlo (MC) simulation, MC and conventional dosimetry were compared for 68 brachytherapy patients treated with Accelerated Partial Breast Irradiation (APBI).

A software tool was developed for the semi-automatic conversion of patient plan dicom-RT exports from commercial TPS to MC simulation input files. Simulations were performed using MCNP5 v.1.6 and results were compared to corresponding dicom RTDose data in the form of isodose distributions, DVH and other plan indices.

While patient specific differences were observed, especially for skin and lung, PTV coverage and conformity index were comparable implying no change is needed in the APBI protocol. The radiobiological evaluation of these results is work in progress.

Acknowledgement

This research has been co-financed by the European Union (European Social Fund-ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning Investing in knowledge society" of the National Strategic Reference Framework (NSRF). Research Funding Program: Aristeia

Paper Number: 0323

A DYNAMIC CARDIAC PHANTOM ASSESSMENT OF THE ACCURACY OF LEFT VENTRICULAR VOLUMES AND EJECTION FRACTION MEASURED BY SIEMENS IQ-SPECT TECHNIQUE COMPARED TO CONVENTIONAL GATED MYOCARDIAL PERFUSION SPECT

Erin Ross, Bethan Roberts, Shane Thomas, Julian MacDonald

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Siemens' IQ-SPECT technology uses astigmatic collimators, cardio-centric acquisition, and advanced 3D iterative reconstruction algorithms to carry out rapid myocardial perfusion SPECT (MPS) in only 4 minutes.

There is very limited information available regarding the clinical validation of IQ-SPECT. Previous studies by other groups comparing IQ-SPECT performance with conventional MPS conducted on a different camera have produced variable results.

This project used a dynamic cardiac phantom to compare the performance of IQ-SPECT to conventional MPS on the same Siemens Symbia camera. Cedars Sinai Quantitative Gated SPECT (QGS) software was used to evaluate the images and obtain EDV, ESV and EF values.

Using the Siemens recommended IQ-SPECT acquisition and reconstruction parameters the percentage difference between the QGS results and the phantom specifications were EDV -57%, ESV -75%, and EF +19%. Comparatively conventional MPS yielded differences of EDV -26%, ESV -24%, and EF 0%.

Altering the reconstruction parameters applied to an IQ-SPECT dataset revealed that only one of the three functional parameters (EDV, ESV or EF) could be optimised for at any one time. Varying the reconstruction parameters applied to a conventional MPS scan allowed all three parameters to be optimised. Although the conventional MPS cardiac volume results were underestimated this was within the range expected when using QGS.

The IQ-SPECT results for the cardiac volumes were substantially worse than expected and resulted in an overestimation of EF which could be clinically significant. The accuracy and validity of the cardiac volumes and EF values is questionable.

Paper Number: 0099

A FAST MODEL FOR PREDICTION OF RESPIRATORY LUNG MOTION FOR IMAGE-GUIDED RADIOTHERAPY: A FEASIBILITY STUDY

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BACKGROUND
Accurate prediction of respiratory lung motion can be an important advance in radiotherapy of lung tumours. Our aim was to study the feasibility of constructing a fast thorax model suitable for simulating lung motion due to respiration using only one CT dataset.

MATERIALS AND METHODS
For each of six patients with different thorax sizes, two sets of CT images were obtained in single-breath-hold inhale and exhale stages in the supine position. The CT images were then analyzed by measurements of landmark displacements due to respiration. Lung and thorax were 3D reconstructed and then transferred to the ABAQUS software for biomechanical fast-finite-element (FFE) modeling, where a linear-elastic material approximation was used. The FFE model parameters were tuned based on three of the patients, and then the model was tested in a predictive mode for the remaining patients to predict lung and thorax motion and deformation following respiration.

RESULTS
During tuning, starting from the end-exhale stage, the model (which was tuned for a patient) created lung wall motion at end-inhale stage that matched the CT image measurements for that patient to within 1 mm (determining its limit of accuracy). In the predictive mode, the mean discrepancy between the imaged landmarks and those predicted by the model (formed from averaged parameters of three patients) was 4.2 mm. The average computation time in the fast predictive mode was 89 seconds.

CONCLUSION
Approximate fast prediction of lung and thorax shapes and positions in the respiratory cycle using a single CT dataset is feasible.

Paper Number: 0163

A METHOD FOR FILTERING OF ZIPPER ARTIFACTS

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In MRI, the hydrogen nuclei are aligned by magnetic fields and excited by radiofrequency (RF) pulses, such nuclei emit RF signals that are captured by a receiver coil. When RF emissions from external sources (e.g., medical devices, computer, radio, TV) are captured by the receiver coil or when there are problems in the system (e.g., fault-circuit, RF inadequate transmission), it produces RF artifacts. A common RF artifact is the zipper artifact, which has a sinusoidal pattern with a width of 1 or 2 pixels, extending throughout the image series. The objective of this paper is to present a method for filtering zipper artifacts. If a certain RF artifact corrupt a number $\xi>1$ of slices of a three-dimensional image with dimensions NxMxS, and is an additive noise, n(x,y), such noise can be considered periodic if the ξ corrupted slices are assembled in sequence, n(x,y,z)=n(x,y,z+1). The zipper artifact meets this requirement, with $\xi=S$. Noises of periodic nature are treated more effectively in the frequency domain. It can be demonstrated mathematically that a three-dimensional image corrupted by a periodic additive noise present in the frequency domain only a corrupt slice ($\xi/2$). The filtering zipper artifacts consists in (1) transform the image series to the frequency domain through three-dimensional fast Fourier transform (FFT) algorithm, (2) transform the center slice to the spatial domain through two-dimensional inverse FFT, (3) filter this slice with the median filter (5x5) and transform back to the frequency domain, and (4) transform the image series to the spatial domain.

Paper Number: 0175

A MULTICENTRE ASSESSMENT OF GEOMETRIC DISTORTION IN 3 TESLA MRI SCANNERS

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INTRODUCTION

Scotland is currently home to six 3Tesla MR scanners. 3T MRI allows the acquisition of high resolution images with good image contrast in acceptable timescales. Geometric distortion arises from static field inhomogeneity and, to a greater extent, non-linearities in the gradient fields and is a greater problem at 3T than at 1.5T. It is critical that we understand the extent to which images are distorted when they are used for interventional procedures or volumetric quantification, where high geometric accuracy is required.

AIM

To measure the geometric distortion on 3T scanners throughout the SINAPSE consortium.

METHODS

Geometric distortion has been assessed using a large, oil-filled geometric phantom ‘CMR 3D Geometry Phantom'[1]. Data has been acquired from six 3T sites. Matlab software has been written to identify the control points within the MR data and compare it to their corresponding location as measured by CT.

RESULTS

Maximum distortions of 7 to 12mm were observed. Distortions have been mapped throughout the phantom volume. The relative performance of the scanners before and after distortion correction algorithms have been applied will be presented.

REFERENCES

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Paper Number: 0230

A NEW APPROACH TO DETERMINE THE REFERENCE AIR-KERMA RATE FROM EXTRAPOLATION CHAMBER MEASUREMENTS

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Since 2008 the Physikalisch-Technische Bundesanstalt (PTB) has been offering the calibration of 125I-brachytherapy sources in terms of the quantity reference air kerma rate (RAKR). The primary standard is a large air-filled parallel-plate extrapolation chamber with thin graphite front and back electrodes. The measurement principle is based on the fact that the air kerma rate at a given point is proportional to the increment of ionization per increment of chamber volume at chamber depths greater than the range of secondary electrons originating from the electrode.

Several methods exist for deriving the RAKR from the measured ionization charges [1]. The most frequently used one is to determine the RAKR from the slope of the linear fit to the so-called ‘extrapolation curve', the measured ionization charges Q vs. plate separations x. Another option is to differentiate Q(x) and to derive the RAKR by a linear extrapolation towards zero plate separation.

For both methods it is a precondition to correct the measured data for all known influencing effects before the evaluation method is applied. However, the impact of the remaining uncertainties to the results is different and the discrepancy is larger than the uncertainty given for the determination of the RAKR with both methods.

A new approach to derive the RAKR from the measurements is investigated as an alternative. The method is similar to the method already applied for the determination of the absorbed dose to water with an extrapolation chamber within a phantom [2]. A comparison of the three methods will be given.

Paper Number: 0375

A NOVEL BIOMAGNETIC APPROACH TO STUDY IN VIVO THE FLOATING LAG TIME OF TABLETS GASTRORETENTIVE.

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An interesting type of controlled drug delivery approach is the floating system. It consists of a gastroretentive system which floats into the stomach and the drug is controlled released to treatment of local diseases. The Alternated Current Biosusceptometry (ACB) is a biomedical technique that has been efficiently used to the evaluation of gastrointestinal tract motility. In this work, three volunteers administered the tablet and remained in orthostatic position in the multisensor measurements apparatus, containing seven sensors, placed on abdominal region. The floating tablet was monitored for 20 minutes aiming to detect the arrival moment of the particles from the stomach and the floating lag time. The analysis of the magnetic signals acquisition showed that the floating lag time occurred in 8 minutes (~500 seconds), since the magnetic signal of one of the sensors presented an intensity peak of signal after the tablet administration and it was decreased during the time when the magnetic signal of another sensor, positioned above, increased. This indicates that the tablet changed its position due to the floatation. So, It can be concluded that it is possible to observe the tablet's floating in vivo and to determine the lag time.

Paper Number: 0305

A PLANNING COMPARISON OF ENERGY, TREATMENT MODE AND MLC TYPE FOR VMAT BASE OF TONGUE RADIOTHERAPY PATIENTS

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PURPOSE

To compare plan quality in terms of dosimetric homogeneity, target conformity, organ-at- risk (OAR) sparing and monitor unit (MU) usages for 10 Base of Tongue tumours patients using RapidArcTM volumetric- modulated arc therapy (VMAT) with both standard and flattening filter free modes. Plans where calculated with both a standard 120 leaf MLC and a HD120 MLC.

METHODS AND MATERIALS

Ten patients were planned using flattened 6MV (standard MLC), flattened 6MV (HDMLC) and 10MV FFF (HDMLC). Treatment planning was performed using Varian Eclipse TM v10.0.39 to generate three 2-arc RapidArc plans for each patient. All plans were optimised with same constraints and normalised to deliver the same mean dose to the planning target volume (PTV). The PTV D99, D95, D5 and D2 where compared as where the standard organs at risk (OAR).

RESULTS

The dosimetric conformity (D99, D95, D5 and D2) of the PTV's was comparable irrespective of MLC type/ energy or of use flattening filter. There was some increase in OAR's sparing with FFF when the OAR was located close to field edge, an average decrease in dose of 6% was observed. An increase in MU of approximately 20% was observed with FFF. The treatment time was comparable irrespective of technique.

CONCLUSION

Dosimetric conformity and OAR sparing was comparable in all plans with the exception of OAR's close to the field edge where a 6% decrease in OAR dose was observed. All planning technique produced clinically acceptable plans.

Paper Number: 0235

A PROPOSED NEW ELECTRON TREATMENT TECHNIQUE.

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There are numerous superficial lesions that can be treated using linac generated electron beams. The areas to be treated are often elongated and the depth of the lesion may vary. Currently electron cutouts have to be customized for every patient and since the advent of MLC's low melting point alloys have to be retained expressly for this purpose. It is therefore desirable to have an automated way to shape electron fields.

Attempts have been made to design electron MLC's but they are all cumbersome and impractical. A novel new electron treatment technique is being developed to solve this problem. A small electron field can be scanned over predetermined paths by moving the couch and gantry synchronously. In this way irregularly shaped fields can be build up. One would also be able to patch a number of fields of different energy together to get a much more conformal dose distribution.

A study is underway to determine the best way to deliver a uniform dose within a reasonable amount of time. This design can make conventional electron cutouts obsolete and may usher in a new era in electron therapy.

Paper number **0017**

A REAL TIME ARABIC SIGN LANGUAGERECOGNITION SYSTEM USING PCA

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Automated sign language recognition is a tool for communication between deaf and vocal people. It is one of the main methods of human-computer interface. There are two approaches to sign language recognition: instrumented glove-based systems and vision-based systems. The Arabic Sign language has not received enough attention as other sign languages such as the American, British, Australian, Chinese and Japanese. This thesis represents a pioneering work on the automation of the Arabic Sign Language recognition using the CyberGlove as an interface device. The principal components analysis is utilized as the feature extraction algorithm to implement a real time system for the automated translation of single handed signs of the Arabic Sign Language Dictionary to a spoken language.

Paper number 0016

A SIMPLE APPROACH TO ESTIMATE THE WEIGHTED CT DOSE INDEX FOR 128 SLICE COMPUTED TOMOGRAPHY

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CT dose index (CTDI) represents the total radiation dose, along the central axis, in a single CT slice. The development of CT technology brings increased demands for quality assurance and requires development of new measurement methods. The current CTDI measurements at 5 peripheral positions and one central position, using the CTDI phantom, can be used to determine weighted CTDI as it is the key parameter that is related to the average patient dose. This sort of measurement would involve considerable time. The ratio of average peripheral dose to central dose, defined as the k factor, has been determined by the RTI, Sweeden for different types of scanners upto 64 slices from which weighted CTDI can be calculated. However, now-a-days the usage of higher slice CTs are increasing and it becomes important to calculate weighted CTDI for these instruments to ensure patient safety. Using five point methods for this purpose becomes time consuming task. Hence, this study aims at calculating the k-factor for 128 slice CT (Make: Siemens & GE Health care) for different tube voltages (100kV, 120kV) and tube current (110mA, 130mA, 150 mA, 180mA, 200mA & 250mA) using five point method. These k-factor values could be used for deriving weighted CTDI for any 128 slice CTs using single point method thus reducing the measurement time considerably. Hence this work provides data required for faster quality assurance of 128 slice CTs.

Paper Number: 0310

A SYSTEMATIC APPROACH TO THE DETERMINATION, PRESENTATION AND REPORTING OF CORRECTED SMALL FIELD RELATIVE OUTPUTS

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Small field dosimetry is difficult, yet consistent data is necessary for advanced radiotherapy techniques. This requires careful standardised measurements, validated Monte-Carlo-based correction factors, and unambiguous methods to report the values, correlating to actual/delivered field size to enable comparison between linacs. Measurements were made at 6MVon Varian iX linacs at different institutions using two un-shielded diodes. Detector-specific output ratios (ORdet) were obtained for square fields of nominal sides 1.0-0.5cm, relative to a square field of side 3.0cm. Five output readings and profiles were obtained for each field, repeating during three independent sessions. Standard experimental uncertainties were calculated for ORdet and field width, defined as FWHM in A(in-plane) and B(x-plane) directions. An effective field size, FSeff = $(A \cdot B)^{1/2}$ using measured widths, was used as the metric to compare the measured ORdet. The appropriateness of using FSeff and linear interpolation between MC-simulated data at nominal field size was investigated and then used to select MC-based correction factors for the small-field detector-specific over-response. Collimated small field size constancy cannot be assumed between linacs, eg, two linac fields with nominal 0.5 cm sides, had measured FSeff of 0.477cm and 0.454cm. Linear interpolation between MC-calculated ORdet validated the electron source FWHM to be 0.10cm and 0.11cm respectively and this allowed appropriate consistent correction factors to be obtained. FSeff is a conceptually simple approach for reporting measured values against the actual delivered field size and provides a standardized method of comparison between linacs. It provides a basis for linear interpolation between tabulated data to provide consistent values.

Paper Number: 0303

ABSOLUTE DOSIMETRIC VERIFICATION OF IMRT/VMAT TREATMENT PLANS USING EPID MEASUREMENTS

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QA verification of IMRT and VMAT treatments plans is a time consuming process. Plans must be re-calculated, measured with a detector array and the results analysed. Whilst this technique is robust and absolute it requires valuable physics time to perform: up to 60 minutes per plan. Electronic portal imaging devices (EPIDs) are also used for QA of IMRT and VMAT treatment plans: this technique is expeditious, has superior spatial resolution (0.39mm pixel pitch) and the measurement may be performed by radiographers for subsequent analysis by a medical physicist. However, as currently implemented it merely verifies the delivered 2D fluence map, rather than performing an absolute 3D dosimetric evaluation. Thus additional steps, such as a point dose measurement in the dose plateau, are required in order to fulfil the requirements for IMRT/VMAT plan verification.

The portal dosimetry algorithm (Varian Medical Systems Inc.) PDIP 10.0.28 has been initially commissioned on a True Beam (VMS Inc.) linear accelerator, with an aSi1000 EPID (VMS Inc.) and Mosaiq 2.41 (Impac Medical Systems Inc.) record and verify system, in accordance with manufacturer's procedure. Furthermore, PTW-Roos chamber and thimble chamber measurements have been performed in order to enable an absolute dosimetric calibration of the EPID at the reference point depth of the commisioned beam energies (X6,X15). In this manner it is possible to streamline patient specific IMRT/VMAT QA workflow in busy radiotherapy departments. Initial results, experience and limitations of this method will be presented and discussed.

Paper Number: 0385

AC BIOSUSCEPTOMETRY TO EVALUATE GASTRIC MOTILITY CHANGES FOLLOWING GASTRECTOMY PROCEDURE

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The gastrectotmy is a surgical procedure that means partial or total stomach recession, causing changes in the gastrointestinal tract (GIT) physiological properties. Several studies show that one of the changes promoted after this surgical intervention is a drastic modification in gastric emptying (GE) and gastric contraction activity (GCA). The biomagnetic methods constitute an interesting alternative for the study of these GIT properties for they are potentially non-invasive, free from radiation and safe. The Alternate Current Biosusceptometry (ACB) is a magnetic method that used inductions coils on the acquisition of magnetic flux variation obtained in response to the magnetic material ingested or fixed in the tract. This paper proposes the analysis of the influences and consequences of partial gastrectomy in GE and GCA by ACB. This work was developed and divided in two steps, before surgery (control) and after surgery. Each step consists of monitoring GE and GCA associated to the digestive process of liquid and solid magnetically marked meals in a group of ten male Wistar rats. From the signals obtained in GIT monitoring, was possible to obtain statistical values showing the relationship between the gastric emptying, arrival cecum time and also the small intestine transit time. For the gastric contraction activity study, the magnetic signal obtained was filtered, processed and analyze. The surgery resulted in significant changes in GCA, as decrease frequency and increase amplitude of contractions, which caused a faster GE.

Paper Number: **0378**

AC BIOSUSCEPTOMETRY AND ELECTROMYOGRAPHY TO EVALUATE UTERINE CONTRACTIONS IN RATS

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Uterus belongs to the group of smooth muscle spontaneously active. Pregnant or not, uterus presents contractions without nervous or hormonal stimulus. Several drugs or hormonal changes may cause uterus contraction variation intentionally or as side effects, and generally these studies are realized in vitro. Alternate Current Biosusceptometry (ACB) is a biomagnetic technique with satisfying results in gastrointestinal and drugs behavior studies and electromyography (EMG) is a well-known method used to record muscles electrical activity. The main objective of this paper was to evaluate the spontaneous uterine contraction in vivo by ACB and EMG using five female Wistar rats with 15 weeks age, approved by the Ethic Committee of Animal Use. A ferrite bead and an electrode was deployed in the uterus muscle serous. The ACB sensor, constituted by two pair of coils (excitation and detection) coaxially organized on a gradiometric configuration, is sensitive to magnetic material displacement providing a mechanical analysis. The EMG records electrical potentials generated on the acting muscle fibers providing an electrical analysis. Both techniques were used simultaneously, with the ACB sensor positioned above the bead and the EMG reference and ground electrodes positioned on the right side of the rat abdomen and on the right leg, respectively. The results were acquired and processed and a contraction pattern with characteristic time and intensity for both mechanical and electrical processes were obtained. Using this results as a normal pattern, will be possible to verify changes on uterine contraction by influence of drugs, pathologies, estrous cycle stages and pregnancy.

Paper Number: 0084

ACCELERATED PARTIAL BREAST IRRADIATION DOSIMETRY ON DIFFERENT BREAST QUADRANT USING 3DCRT AND IMRT

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PURPOSE

Breast conserving Radiotherapy (BCT) is standard for stage I and II breast cancer. Multiple randomized trials have shown that recurrences after lumpectomy occur mainly in or close to the tumor bed with no significant effect for whole breast radiotherapy on the recurrence in remote areas of the breast. We are conducting a treatment planning studies comparing dosimetric data for IMRT and 3DCRT and the effect of tumor location on the doses to the organs at risk.

MATERIALS AND METHODS

CT planning data sets for33 patients (12L & 22R) with tumor size less than 3 cm and negative axillary lymph nodes were used for our study. Regarding tumor location, 5 were located in the central , 4 inLI, 4 in LO, 10 in UI, and 10 in UO quadrant. Both 3DCRT and IMRT plans were created for each patient. Total dose of 38.5 Gy in 10 fractions were planned. Dosimetric analysis were done for three categories 1) 3DCRT 2) IMRT 3) location of tumor.

RESULTS

The target coverage has been achieved by both the methods but IMRT provided better coverage with CI. Dmax were well controlled in IMRT to below 108%. Heart V5, Lung V5, Lung V10 was higher with conformal therapy compared to intensity modulated therapy. Tumors located in the inner quadrant were associated with relatively higher doses to the heart and left anterior descending coronary artery doses with both modalities.

CONCLUSION

Dosimetrically IMRT -APBI provided best target coverage with less dose to normal tissues compared with conformal therapy.

Paper Number: 0396

ACCURACY , UNCERTAINTIES AND LIMITATIONS IN RADIOTHERAPY DOSE DELIVERY: HAVE MODERN TECHNOLOGY AND METHODS CHANGED OUR VIEWS?

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Increased complexity of dose delivery using modern radiotherapy technology requires greater attention to accuracy, QA and verification. Despite all the data generated, eg from pre-treatment verification and in vivo dosimetry, it has been unclear whether overall accuracy has improved or not.

Starting points were, a) a recent updating review by Thwaites (Proc IC3DDose, JPhys:Conf Ser, 2013) of whether new technology has changed the accuracy required and achievable in radiotherapy dosimetry; and b) a review by Schreiner et al (same proceedings) of practical concerns for g and c evaluation of delivered-vs-planned dose distributions. From these, the uncertainties and limitations in dose verification and accuracy assessment for complex dose distribution delivery were reviewed. This includes measurement systems, methods and parameters; data selection, analysis and tolerances; and results selection, presentation and interpretation.

The impacts of these uncertainties and limitations are quantified, both on the identification of deviations for verification and on estimates of accuracy achieved. Using this framework, it has been possible to re-consider the analysis of information from pre-treatment verification, in-vivo dosimetry and audits for IMRT and of some observations around the use of g-index data for accuracy of dose delivery.

There are a range of practical considerations in the methods of verification and accuracy assessment that can compromise the integrity of the tests and conclusions. However, earlier evidence-based estimates of accuracy achievable are still generally valid, despite the technology changes, with the greatest general change in overall accuracy being from the significant impact of image-guidance on both geometry and dose delivery.

Paper Number: 0313

ACCURACY VERIFICATION OF COMMERCIALLY AVAILABLE DEFORMABLE IMAGE REGISTRATION ALGORITHM USING 4D-CT IMAGES

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INTRODUCTION

We verified the accuracy of B-spline deformable image registration algorithm implemented in a Velocity AI ver. 2.7.0 software (Velocity Medical, GA, USA) in each area of the lung region using thoracic four dimensional computed tomography (4D-CT) images.

MATERIAL AND METHODS

For verifying the accuracy in each area of lung region, we calculated registration error (RE) which was defined as the difference between deformation field (DF) and the designated reference standard displacements using we 4D-CT images including 300 landmarks / case, throughout the lung, five patients, provided by DIR-lab (www.dir-lab.com). First, manual displacement (MD) was calculated by land mark points. Next, DIR outputs were calculated by a Velocity AI and created DF using in-house program. After that, we divided MD and DF into ten segments on equal thickness. Last, RE was calculated from MD and DF for each of the segments corresponding. We defined the RE in the segment of the top in the lung region as RESeg1, bedrock RESeg10.

RESULT AND DISCUSSION

RES was 1.99 mm in segments at the top, was 5.74 mm in the bottom segment. RE showed a tendency to increase in this way as it became the lower part, but was less than 3.0 mm to RESeg6

CONCLUSIONS

We verified the accuracy of the Velocity AI in each domain of the lung region. Our result clearly shows that the Velocity AI has precision within 3.0 mm to RSEeg6. Therefore commercially available algorithm may be useful for adaptive radiation therapy.

Paper Number: 0201

ACTIVE OXYGEN GAS-DISCHARGE GENERATOR FOR BIOMEDICAL APPLICATIONS

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The main goal of research work was to design a gas-discharge active oxygen generator, for the treatment and rehabilitation due to useful properties of the active oxygen. Oxygen was used as a working substance for getting active oxygen. The analysis showed that gas-discharge process of getting active oxygen is the most appropriate for medical purposes.

During the work was created a gas-discharge active oxygen generator. Structurally, the gas-discharge generator is designed as a miniature device. The operating principle of the generator is: plasma forming gas is injecting with pressure up to 1.5 bars into the gas-discharge generator through the inlet nozzle. After passing through the channel, within the device, it enters into the discharge chamber of the generator. Also, experiments were conducted, where as plasma forming gas was used oxygen-air mixture obtained by the SAM-1 generator. During the work, experiments were carried out such as distribution of the average bulk temperature, current-voltage characteristics and spectrum characteristics, which show high levels of various reactive oxygen species, intense lines of O,O+,N,N+, the bands of the molecules O2,O2+,O3,N2,NO, and atomic lines of elements of the electrode material.

The experiments results showed that the generator allows getting plasma flow, which contains active forms of oxygen, with favorable parameters for biological objects[1]. Thus, we managed to get a device that can be used for biomedical technology and microelectronics.

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Paper Number: **0392**

ADAPTIVE CONTROL OF BIOMECHANICALLY INSPIRED ORTHOTIC EXOSKELETON

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The inception of robots was planned to assist humans in various aspects from working in hostile environments to material handling processes that demands repeatability and accuracy. The reaches of human-robot interaction has not been visualized merely for any information transfer but tried to extend it to corporal and cognitive interactions. One such interest falls into the realm where robots can be utilized to extent the strength of human beyond their natural limits. As a part of rehabilitation robotics this project aims at the development of a lower extremity biped exoskeleton to aid paralytic people. In order to be stable and robust, the exoskeleton must be a highly adaptable model, which is accomplished by integrating a perfect biomechanical design with computationally intelligent control. The exoskeletal prototype by itself stabilizes the posture, adaption to any terrain using robust gait paradigms. The acquainted results can then be compared with standard models and further optimization can be facilitated.

Paper Number: 0208

AN EVALUATION OF GOLDANCHORTM INTRAPROSTATIC FIDUCIAL MARKER STABILITY DURING THE PROSTATE CANCER PATIENTS RADIOTHERAPY

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BACKGROUND
Implantation of fiducial markers for IGRT of prostate cancer patients increases the treatment accuracy. However the precision of the treatment depends on the stability of the fiducial marker. The aim of this study was to evaluate the migration of fiducial markers during the prostate cancer radiotherapy.

MATERIAL AND METHODS
An analysis of the intraprostatic fiducials migration was done on a group of 25 patients treated with IGRT. The migration value was determined by comparison of the marker's position checked once a week using CBCT. Migration of the marker within the prostate has been assessed by measuring the distance between the focal point marker, in all three directions.

RESULTS
The average values of the GoldAnchorTM migration were: 0.01 cm (SD=0.02) in the superior-inferior (SI) direction, 0.01 cm (SD=0.03) in the left-right (LR) direction and 0.02 cm (SD=0.04) in the anterior-posterior (AP) direction. The spatial form (degree of compression the wire) of the marker does not affect the value of migration (p>0,05). The average value of the vector of the changes was 0.03 cm (SD=0.05). The largest measured value of migration was 1 mm and was observed in all three axes. The displacement of the marker was not observed in 76% of the measurements in any of the axes. The migration was not observed in SI, LR and AP axis in: 94%, 88% and 85% cases, respectively.

CONCLUSION
The analysis showed that intraprostatic fiducial markers (GoldAnchor®) are comparatively stable inside the prostate during the whole radiation therapy.

Paper Number: **0391**

AN UPPER LIMB PARALYSIS REHABILITATION ACTIVITY MONITORING DEVICE FOR POST TRAUMATIC STROKE PATIENTS

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The aim of this project is to develop a portable wearable device that can be continuously monitoring the rehabilitation activity for post-stroke patients. This device has Wireless wearable sensor system it continuously sensing the upper limb range of motions. Accordingly, these data are processed by microcontroller then transmitted through zigbee wireless protocol to personal computer for further data analysis. This experimental set up has been developed in order to provide the information of rehabilitation activity and also can be used to measure the improvement rates. This entire system has consists of two modules. First module is designing hardware part of the device. Second module related to data acquisition from subjects. First module aims to increases the wear ability and suitability of hand glove for mounting multiple sensors on it and designing microcontroller part for data processing. In second module the device has to test the normal and paralyzed subjects for comparative analysis.

Paper Number: 0058

ANALYSIS OF CONVENTIONAL COMPUTED TOMOGRAPHY, KILOVOLTAGE AND MEGAVOLTAGE CONE BEAM CT IMAGES

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Images of Catphan Phantom 504 were taken with clinic protocol using different devices and techniques, for a quantitative study. The parameters analyzed were slice thickness - percentage difference between the thickness of the actual slice and the one obtained with recommendations of the phantom manufacturer, circular symmetry (measured between known distances in the axial plane in the horizontal and vertical axes), uniformity, spatial resolution and noise. It was also studied the linearity of CT numbers on a graph whose abscissa is the CT number expected by the manufacturer and the ordinate is the obtained for each imaging technique. All analyzes were made using the software ImageJ. The percentage difference between the nominal slice thicknesses (3 mm) obtained, in the worst case, resulted in - 10.7%. The circular symmetry obtained in all images was less than 3%, showing small geometric distortion in image reconstruction. The uniformity obtained for all images were within the expected range, according to the specifications of each manufacturer. Noise analysis showed an average of 0.6% for conventional tomography, 1.4% for kilovoltage cone beam and 4.5% for megavoltage cone beam. Best spatial resolution was found in kilovoltage cone beam, which was possible to differentiate 8 line pairs per centimeter, and the worst was for megavoltage cone beam, with 2 line pairs per centimeter. Finally, analysis of CT numbers showed that the relationship between the expected and obtained is linear for all techniques, differing mainly by absolute values in MV cone beam technique, as expected.

Paper Number: 0352

ANALYSIS OF POSSIBLE MISTAKES OF IRRADIATION FROM RESULTS OF IAEA TLD AUDIT OF DOSE CALIBRATION QUALITY IN RADIOTHERAPY

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Since 1998, Ukraine has been participating in the IAEA/WHO TLD postal audit of dose calibration quality in radiotherapy. Unfortunately the results of TLD-audit show that the TLD-audit of 25-30 % radiation beams were not acceptable because the errors had been exceeded the 5% acceptance limit. The analysis of the distribution of errors of TLD-audit with unacceptable results showed: the errors in the range of 5-10 % were observed in 58 % cases, in range of 10-20 % - in 32 % and more than 20 % - for 10 % cases.

To establish the sources of errors the results of questionnaire of radiotherapy departments and the data sheets of TLD audit were analyzed. The potential sources of errors during TLDs irradiation had been found. The errors of 5-10% range could be associated with: the using of obsolete dosimeters 27012 and VAJ-18 with calibration error near 5-7 %; the differences in values of the constants in calculation absorbed dose algorithms from reference literature; irregular accounting of source decay etc. The errors 10-15% could be related with irradiation technique which was used for irradiation of TLD capsules and calculation of doses (SSD or SAD-technique); the absence of correction factor from Air kerma to the absorbed dose in water if dosimeter was calibrated in Air kerma units. Errors over 20 % could be related with calculation of the irradiation time for depth 5 cm and irradiation of TLDs in holder with depth 10 cm; different random errors of the exposure time calculation.

Paper Number: 0215

ANALYSIS OF SEED LOSS AND SEED DISPLACEMENT AND ITS DOSIMETRY IMPACT IN PROSTATE CANCER PATIENTS TREATED WITH LOW DOSE RATE BRACHYTHERAPY

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PURPOSE
To investigate seed displacement and how it affects post implant dosimetry.

METHODS
Data from 218 consecutive patients was analyzed. Prescription was 145 Gy minimum peripheral dose to prostate. I-125 seeds were used with loose seeds in the center and stranded seeds in the periphery. Typically, we planned with inferior most seeds 2.5 to 7.5 cm below prostate to cover the apex. Procedure was done under trans-rectal ultrasound guidance and post implant dosimetry was done using CT/MR fusion one month after implant. Treatment planning was conducted on VariSeed 8.0. Seed loss and displacement were evaluated with the help of X-rays of chest and pelvis and CT /MRI of pelvis, and its impact on prostate dosimetry analyzed.

RESULTS
Mean number of inferior seeds was 9.2 and 8.2 for pre- and post-plans respectively. 83% of post-implant inferior seeds were within 9 mm from prostate apex. Post implant prostate length was not significantly different from pre plan (mean difference was 0.3 mm) and the difference was within 3 mm for 78.3% and 6 mm for 98.2% of patients. Overall 40% of patients experienced seed loss; 15.5% of patients had seed loss to lung, 10.5% to abdomen/pelvis, 3.0% in urine, and 20.0% unknown destination. Post plans with V100% >=85% and D90 >=90% were considered optimal. Mean post-implant prostate V100 was 94.8% and D90 was 114.3%. 2.8% of patients had V100 < 85% and 1.4% had D90 < 90%.

CONCLUSIONS
Seed displacement did not significantly affect patient dosimetry in this study.

Paper Number: 0061

ANALYZING PHYSICAL DOSE DISTRIBUTION OF IMRT PLANNING AND PATIENT QUALITY ASSURANCE RESULTS FOR H&N CANCER PATIENTS: REVIEW OF NASSER INSTITUTE EXPERIENCE

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PURPOSE

Analyze the physical dose distribution generated by IMRT investigating the influence of different planning parameters. Evaluate patient specific quality assurance results for H&N cancer patients. Assess different gamma methods in evaluating intensity modulated fields dose maps.

MATERIAL AND METHOD

Due to accidental collision between gantry and linac couch, ten patients with nasopharynx cancer were inverse planned IMRT using 7 fields avoiding under couch fields. Dose constrains and priorities for PTVs and OARs were defined. A hybrid plan with the same fluence maps as in the treatment plan was generated on a phantom. Points of measurement using ion chamber were typically located in the region of isocenter. Other hybrid plan was generated on 2D array of ion chambers sandwiched between 5cm of slab phantoms to analyze the intensity pattern of the IM fields. Comparison of absolute gamma and relative gamma results has been made.

RESULTS & CONCLUSION

It is possible to achieve accepted dose distribution in nasopharynx cancer patients using a limited gantry angles depending on the hard dose constrains and the previous experience of driving the optimizer to the optimal solution. For hybrid plans, good consistency was observed between measured and calculated Isocenter doses. Gamma evaluation through 2D array measurements reflects the accuracy of the delivered fluences by 95.1% with SD of 2.4 using absolute gamma method and 61.8% with SD of 6.3using the relative gamma method. Comparison with absolute γ method pretends better gamma results than comparison with relative method but it is less sensitive in low dose area.

Paper Number: 0325

APPLICATION OF SIZE SPECIFIC DOSE ESTIMATION (SSDE) TO CT PATIENT DOSE AUDIT.

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In 2011 the American Association of Physicists in Medicine (AAPM) released report 204 ‘Size Specific Dose Estimates (SSDE) in Pediatric and Adult body CT Examinations'. This report aims to ensure that the dose values which are reported by CT scanners are adjusted to provide a better estimate of the individual patient dose. The CTDIvol values which are reported by the scanner are based on either a standard 32 cm or 16 cm diameter PMMA CTDI phantom. The size of standard phantom used in dose determination is likely to be based on the scanning protocol selected and may not represent the actual size of the patient. Incorrect phantom selection can lead to indicated doses which underestimate the actual dose by a factor of 2 to 3. This may be particularly important for estimating doses to paediatric patients.

The AAPM method encourages measurements of each patient's Anterior-Posterior (AP) and Lateral (Lat) dimension and based on these measurements suggests a conversion to provide a better estimate of the dose received by each patient.

Results will be provided comparing this method with more traditional techniques, when carrying out CT patient dose audits.

Paper Number: 0349

ASSESMENT OF DOSE CALCULATION ALGORITHM IN STEREOTACTIC RADIOTHERAPY (SLRT) OF SMALL LUNG LESIONS: CT-BASED PATIENT AND LUNG PHANTOM STUDY

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In lung SLRT, the presence of inhomogeneities in combination with small field sizes and a high dose per fraction becomes a dosimetrical challenge. The choice of the dose calculation algorithm has shown to be crucial to ensure more accurate dose delivery to the patient.

Our study aim to investigate the influence of the calculation algorithm and the calculation grid size in lung SLRT planned on 4D-CT patient images and a CIRS thorax phantom.

Five patients with small lung lesions treated with hypofractioned radiotherapy (4 × 12Gy) were evaluated. Treatment plans consist of 7-9 non-coplanar beams of 6MV. Dose calculations were primarily optimized with the analytical anisotropic (AAA) algorithm on the 4D- CT patient images and subsequently recalculated with the pencil beam convolution (PBC) algorithm using identical MUs. Dose calculations with 1, 2 and 3 mm grid were evaluated. Experimental validation was performed with ionization chamber in the CIRS phantom. Dose calculations were also made on the CT scanned phantom.

Using AAA algorithm, the V100% for the PTV increases up to 10% as the calculation grid size decreases from 1 to 3mm, in particular for treatments using 9 beams. The PBC algorithm overestimates within 10 – 15% the prescribed dose in the target, however no differences were observed in the critical structures. Overall, the AAA algorithm is closer to measurements (1.5%) than the PBC algorithm (4%).

Our results show that the use of AAA algorithm with a 1mm grid size seems to be an excellent combination for more accurate lung SLRT.

Paper Number: 0328

ASSESSING THE INFLUENCE OF CT SCANNING PARAMETERS ON AEC PERFORMANCE

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Automatic Exposure Control (AEC) Systems have become an integral part of CT scanning protocols. However, because they are automatic, the operator of the equipment may be unaware of the how the AEC system works and interacts with user-selectable parameters.

Since the function of the AEC has a significant impact on patient dose and image quality, the Medical Physicist can play a valuable role in both assessing the system during equipment testing and assisting radiology staff to optimise the scanning protocols.

In assessing the performance of the AEC system it is important to determine how it works, that it is functioning correctly and the effect of altering user-selectable parameters. It also requires the use of a suitably designed phantom which can cause the AEC system to modulate the exposure appropriately.

In this study we have used the CeIT phantom, a locally designed and manufactured elliptical test tool, which enables us to monitor the effect of AEC system performance on CT number, image noise and Contrast to Noise Ratio (CNR) for a range of materials, including contrast agents.

Results will be presented which highlight the influence of a range of scanning parameters including: single projection radiograph (SPR) - anterior-posterior or lateral selection, mA modulation mode, scan direction, kV selection and use of contrast agents.

Paper Number: 0034

ASSESSMENT OF PATIENT DOSE IN COMPUTED TOMOGRAPHY: COMPARISON OFADULT AND PEDIATRIC RADIOLOGY PRACTICE IN KING HAMAD UNIVERSITY HOSPITAL

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The assessment and calculation of radiation dose in Computed Tomography CT is a very important factor for efficient dose management. Volume Computed Tomography Dose Index (CTDIvol) and Dose Length Product (DLP) are the quantities proposed by international agencies as diagnostic reference levels (DRL) for CT. The objective of this study is to assess typical patient dose from adult and pediatric CT examinations. King Hamad University Hospital KHUH was enrolled into the study. The hospital has a high workload. A single detector CT was considered, to represent typical practice in KHUH. Due to the fact that it is very difficult to make measurements in groups of patients that differ a lot in size, we did the measurements on all patients undergoing the specific procedure for a measuring period and then took the average of these measurements. We included 300 patients in this study. The exposure parameters based on predefined protocol for CT examinations of head, chest, abdomen and pelvis were analyzed. Data were taken from CT unit display. These includes exposure parameters, Volume Computed Tomography Dose Index (CTDIvol) and Dose Length Product (DLP). Also, the Effective Dose E was estimated for each protocol. The assessed patients' doses in terms of CTDIvol and DLP were within reference levels and in accordance with surveys from other countries, however the scope for dose reduction through optimization of the examination protocol was considered.

Paper number: 0005

ASSESSMENT OF PEADIATRIC RADIATION DOSE FROM ROUTINE X-RAY EXAMINATION: A HOSPITAL BASED STUDY, TAIF PEDIATRIC HOSPITAL

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INTRODUCTION AND RESEARCH PROBLEM

Radiological imaging is an important part of today's overall healthcare practicum, Imaging can begin as early as the first day of life but as children are more sensitive to radiation than adults special care should be in place . The main aim of the current study was to determine Entrance Surface Dose (ESD) to pediatric patients as the result of imaging procedure, in main pediatric hospital in Taif city - Saudi Arabia for the first time.

RESEARCH METHODOLOGY

110 patients underwent different examinations (chest, abdomen , skull , and extremities) , age range from 0-15 years .The patients biodata (age , weight, height ,Gender) were recorded. The exposure factors ,focal skin distance, tube output and back scatter factor were entered in special soft ware known by DOS CAL in order calculate the ESDs.

MAIN RESULTS

The mean ESD obtained ranged 0.18 -0.32 mGy per radiograph for different ages and groups. No correlation coefficient was found between patient size (age or weight) and ESD, but significant correlation detected between ESD and tube potential difference (kV) encountered in these examinations .

CONCLUSION AND RECOMMENDATIONS

The results were agree and compatible with literature. The radiation dose can be reduced more by optimization of each investigation and hence more studies is required for this task The results presented will serve as a baseline data needed for deriving local reference doses for pediatric X-ray examinations in this local department and hence it can be applied in the whole Kingdom.

Paper Number: 0085

ASSESSMENT OF THE RADIATION OCCUPATIONAL DOSE FOR NON-RADIATION-WORKERS IN THE MEDICAL FIELD AT HAMAD MEDICAL CORPORATION HOSPITALS IN QATAR

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The aim of any radiation protection program is to reduce the radiation dose to individuals (patient and staff) to the lowest possible level below the Maximum Permissible Limit (MPD) determined by the national or international laws. While the purpose of the Dose Monitoring Program is to scale and evaluate the efficiency of the radiation protection programs for collective staff working in different departments. Also, to evaluate the efficiency of the radiation safety requirements especially the shielding adequacy. In this study for example, the average staff annual Eff dose for the Intensive Care Units at Hamad General Hospital was less than 50% of MPD.

Paper Number: 0393

AUTOMATION OF WHEEL CHAIR USING ULTRASONICS AND KINEMATICS

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Physically disabled persons find their movements very tough with the existing assistive devices. Though there are many robotics available in recent times to enable their motility they require fine and accurate control which is most of the times not possible in cases of higher disability. These robots are very efficient and enable the user to move around with ease. In recent times there have been various control systems developing specialized for people with various disorders and disabilities. This paper reports the preliminary work in developing a robotic wheelchair system that involves the movement of eyeball and shoulder kinematics in directing the wheel chair. Our system allows its users to tell the robot its direction of movement and will also sense and alarm the user about the obstacles in the path to avoid collision. This wheelchair system is a general purpose navigational assistant in environments with ramps and doorways of little space to allow a wheelchair pass. This work is based on previous research in robot path planning and mobile robotics, generally a robot should be interactive, and robotic wheelchairs must be highly interactive to enable the system to work most efficiently. This project involves three sensors namely IR sensor, Ultrasonic sensor and a pressure sensor.

Paper Number: **0366**

CAN 2D DOSIMETERS DETECT SYSTEMATIC DELIVERY ERRORS IN IMRT PLANS?

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Two IMRT QA devices were evaluated for their ability to detect systematic delivery errors in patient-specific plans.

Two clinical step-and-shoot IMRT plans were selected, one simple prostate and one complex head and neck (H&N). Eleven plan variations with errors introduced were created: Multi-Leaf Collimator (MLC) positional errors (all leaf pairs shifted in the same direction (1, 2, 3, 4 mm) and opposite direction (1, 2, 3 mm)) and collimator rotation offsets (1, 2, 3, 5 degrees). Plans were measured using an Electronic Portal Imager (EPI) and MatriXX Evolution ionisation chamber array. The measured dose for each field was compared to the calculated dose for the 'no error' plan using Gamma analysis with 3%/3mm, 3%/2mm, and 2%/2mm criteria.

In general, pass rates reduced as errors increased. Pass rates also reduced as the gamma criteria reduced. The prostate plan was more sensitive to MLC errors while the H&N plan was more sensitive to collimator errors for both detectors. For the 3%/3mm criteria, the pass rates of both detectors were within 5% of each other for small errors but the MatriXX was more sensitive to errors >3 mm or 3 degrees. For the H&N plan, pass rates were 90.6±2.8%, 95.4±1.8% and 68.6±3.2% for the EPI; and 81.6±3.7%, 93.9±2.4% and 62.5±2.5% for the MatriXX; for the largest MLC shift, same and opposite direction, and collimator errors respectively.

The ability of both devices to detect delivery errors was similar. Neither device could reliably detect MLC positional errors which were outside recommended tolerances.

Paper Number: 0400

CAN VMAT BASED SBRT BE AN OPTION IN PATIENTS UNSUITABLE FOR INTRA CAVITORY BRACHYTHERAPY IN LOCALLY ADVANCED CANCER CERVIX?

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PURPOSE

The purpose of this study is to compare standard ICRT plans with VMAT based SBRT.

MATERIALS & METHODS

CT Data sets of ten patients who underwent ICRT were used in the study. In all these patients a total Dose of 7Gy was prescribed to Point A. Rectum Bladder & other normal structures were contoured on the ICRT CT data set, which were transferred to Eclipse TPS along with the 150%-50% Isodose volumes. Dosimetric parameters such as Conformity Index (CI100), Homogeneity Index(HI), were calculated for PTV along with Bladder Rectum partial volume doses.

RESULTS

The average CI100 for RA plans were 1.11 + 0.07 whereas averages HI were 1.549 + 0.19 & 8.61 + 0.15 for RA & ICRT plans respectively. The average 1cc, 2cc, 5cc volume & mean doses of bladder for RA plans were 1.83Gy, 0.98Gy, 0.54Gy, & 0.40Gy less than ICRT plans. Similarly the average 1cc, 2cc, 5cc volume & mean doses of rectum for RA plans were 0.30Gy, 0.43Gy, 0.80Gy, & 0.94Gy less than ICRT plans.

CONCLUSION

The results obtained in our study suggest that there may be a dosimetric advantages to use Image guided SBRT for patients with significant residual disease at the end of External Radiotherapy. Considering the above fact and the encouraging result from this study have made us to start a limited clinical trial evaluating VMAT based SBRT using MR based target delineation for patients unwilling to undergo interstitial Brachytherapy at the end of external radiotherapy after being declared unsuitable for ICRT.

Paper Number: 0324

CAN WE GO BELOW 60 KV? AN ASSESSMENT OF IMAGE QUALITY WITH THE USE OF LOW KV RADIOGRAPHIC EXPOSURES.

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Radiographic literature and practice are normally concerned with the use of tube potentials in excess of 60 kV. This is due to the increased patient dose implications of using less than 60 kV, since the tube current is required to be increased to achieve adequate penetration. However, with the advance in signal and noise handling properties of modern image receptors it was hypothesised that for small objects it may be possible to offset the increased image contrast in low kV exposures with a reduction in the acceptable receptor dose.

Contrast-noise-ratio measurements were made in a contrast detail test object to compare the image quality at 40, 50, and 60 kV. The patient dose, as registered by the kerma area product (KAP), was held constant for the three beam qualities and the relationship between tube potential and image quality investigated for different object thicknesses by adding polymethyl methacrylate (PMMA) slab material.

At a constant patient KAP, exposures below 60 kV can result in an improved CNR for small object sizes, however, there is variation between different image receptors. The test object CNR measurements indicate that consideration could be given to the use of low kV exposures for small object thicknesses. More work is required to understand the clinical implications such as the range of examinations and patient sizes to which this may apply and to investigating the image quality-dose trade-off for equivalent sizes of bony detail.

Paper Number: 0257

CEREBRAL VENTRICULAR VOLUME MEASUREMENTS FROM MR IMAGES.

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Cognitive decline and dementia is a growing concern in an ageing population. Quantitative measurements of brain volume become increasingly important in investigations of age-related cognitive decline. This work focuses on investigating reproducibility of two automated segmentation software packages; FreeSurfer (USA) and FSL (UK), for volumetric measurement of cerebral ventricles.

Twenty healthy volunteers underwent two subsequent 3D head MRI examinations on a 3.0T Philips Achieva and a 1.5T GE Nvi including T1-w axial volumes. Volumes derived with each segmentation method were compared to check for reproducibility. Spatial agreement of both segmentations was investigated using percentage-volume-overlap (PVO) and percentage-volume-difference (PVD).

Bland-Altman analysis showed that volumetric estimates computed with both methods were not reproducible (mean volume difference of 16.68cm3). Volumes estimated with FreeSurfer (mean 15.48±6.6cm3) were found to be in a better agreement with previous studies. Results obtained with FSL (mean 32.16±10cm3) overestimate ventricular volumes when compared to FreeSurfer and previous studies. PVO and PVD were found to be 56.21±9.14% and 70.79±12.9% respectively. Large volume differences were attributable to a non-optimised segmentation mask for FSL. An in-house designed segmentation mask allowed improving spatial agreement between methods (PVO and PVD of 72.86±5.85% and 54.12±11.91% respectively). The across-scanners volume measurements resulted in a statistically significant volume difference bias ($p<0.05$) for both methods that should be taken into account when designing multi-site studies.

Both segmentation methods experienced a large variability on volume differences for across-scanner measurements. Large variability may not allow distinguishing between control and patient groups once results are mixed together in multi-site studies.

Paper Number: 0245

CHALLENGES OF PSEUDO-CONTINUOUS ARTERIAL SPIN LABELLING IN CLINICAL USE OF PATIENTS WITH SEVERE BRAIN DYSFUNCTIONS.

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Arterial spin labelling (ASL) technique of magnetic resonance imaging (MRI) is becoming more popular in clinical use as it measures qualitatively and quantitatively haemodynamic functions of both perfusion (blood flow) and arterial blood volume. ASL found its use mostly in the brain, but it is also used in other internal organs. There are many ASL sequences and Pseudo-continuous ASL (pCASL) approach is particularly attractive to clinicians as it provides several advantages over other techniques, such as increased signal-to-noise ratio, whole head coverage and relatively easy quantification models. There are, however, certain challenges involved with positioning of the tagging plane, which require prior anatomical knowledge of subject's carotid arteries, as this is where the tagging occurs. In healthy subjects the problem is easily recognised and, therefore, can be corrected by changing the position of the tagging plane and adjusting labelling duration and delay. This method becomes slightly unreliable when it comes to imaging severely altered brains such as of comatose, vegetative state or locked-in syndrome patients. In many of those cases perfusion deficiency can occur globally as well as regionally. Poor labelling (due to patient's anatomy and positioning of the labelling plane) can manifest itself as perfusion deficiency giving false results. Therefore it is important to perform additional anatomical scan of the area around the labelling plane to avoid any tortuousness or even slight bending of the arteries. Correctly assessed haemodynamic brain functions could be highly beneficial to the recovery prognoses of those patients.

Paper Number: 0253

CHARACTERISATION OF MOSKIN™ DETECTOR FOR IN-VIVO SKIN DOSE MEASUREMENT DURING MEGAVOLTAGE RADIOTHERAPY

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INTRODUCTION

In-vivo dosimetry is very important to ensure the accuracy of dose delivered to the treatment volume. A dosimeter should be characterised based on its application before it is used for in-vivo dosimetry. In this study, we characterised a new MOSFET-based detector, the MOSkin™ detector on surface for in-vivo skin dosimetry. The advantages of the MOSkin™ detector are its water equivalent depth of 0.07 mm, small physical size with sub-micron dosimetric volume, ability to get real-time instant readout.

MATERIALS AND METHODS

A MOSkin™ detector was calibrated and the reproducibility, linearity and response to different threshold voltages were determined. Surface dose on solid water phantom was measured using MOSkin™ detector and compared to Markus ionisation chamber and Gafchromic EBT2 film measurements. Dependence in the response of the MOSkin™ detector on the surface of solid water phantom was also tested for (i) different field sizes, (ii) different SSD, (iii) different radiation incident angles, (iv) repetition rate, and (v) beam energies.

RESULTS

The MOSkin™ detector showed excellent reproducibility and linearity for dose range of 50cGy to 300cGy. The surface doses were 15.8 %, 19.1 %, and 23.0 % measured using Markus ionisation chamber, MOSkin™ detector, and Gafchromic EBT2 film respectively. The MOSkin™ detector showed small dependence to different field sizes, SSDs, radiation incident angles, dose rate, and beam energies.

CONCLUSION

The MOSkin™ detector is suitable for in-vivo skin dosimetry due to its excellent physical characteristics.

Paper Number: 0064

CHARACTERIZATION OF A DEDICATED HEAD SPECT SCANNER

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PURPOSE
Characterize a SPECT system with a scanning geometry and detector arrangement specialized for the head.

METHODS
The Neurologica inSPira HD is a dedicated head SPECT system consisting of 72 detectors in a rotating clamshell geometry and permanent focused-cone collimators. The small ACR phantom was scanned multiple times with varying activity levels of Tc-99m. Resolution (MTF and ACR rod groups), contrast (ACR spheres), noise (MTF and COV), and integral uniformity were compared under varying scanning conditions.

RESULTS
The inSPira was able to resolve rods 7.9mm and greater and spheres 12.7mm and greater. Contrast was generally higher than conventional systems. COV was relatively high at 3.0. Integral uniformity of the inSPira was 6.9 and unknown scan artifacts were found under certain conditions. Spheres demonstrated low partial volume artifact due to improved resolution. NPS demonstrated reduced high frequency noise when attenuation correction (integrated into the OSEM/MLM reconstruction method) was applied. MTF was generally high in all dimensions and under all scanning conditions.

CONCLUSION
The Neurologica inSPira HD demonstrated high resolution, contrast, and reduced partial volume artifact. Noise and uniformity were poorer, but still acceptable. Artifacts were seen under certain scanning conditions. The unique scanner configuration makes the cause of these artifacts unknown and further investigation is necessary. Clinically, the improved resolution and contrast of the system may lead to more accurate mapping of the brain and size estimation of lesions.

Paper number 0185

CHARACTERIZATION OF ALANINE EPR DETECTOR RESPONSE IN CLINICAL PROTON BEAMS

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Physical dose is the quantity used in clinical quality assurance and to dosimetric characterize the beam in proton radiotherapy.

Among solid state detectors the alanine EPR detectors present several advantages such as tissue equivalence, linearity of dose-response over a wide range, high signal time stability, no destructive read-out procedure. These features make alanine a good candidate for quality assurance of clinical proton beams.

The goal of the present work is to investigate the response behaviour of alanine EPR pellets in a passive scattering beam (maximum energy 70MeV) and in an active spot-scanning beam (maximum energy 230MeV).

Regarding the passive scattering modality used in eye melanoma treatment, Output Factor measurements have been carried out and the results compared with other dosimetric techniques.

Moreover, regarding the spot-scanning technique used to treat deep-seated tumour, the dose linearity alanine response in the clinical dose range has been verified and the alanine dose response at selected locations in depth has been measured and compared with the TPS planned dose in a quasi-clinical scenario.

Furthermore, we aim at understanding the influence of fading and the power saturation characteristics of the EPR signal in alanine pellets exposed to different LET .

Paper Number: 0131

CHIRAL PREFERENCE OF TETRAVALENT POLYAMINES IN DNA COMPACTION

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Polyamines are ubiquitous in living cells and have an essential role for many biological processes including regulation of gene expression. In addition, synthetic polyamine analogues are expected to provide potent antiproliferative drugs that can be used in cancer chemotherapy. In the present, we prepared four chiral isomers of tetravalent polyamines with four chiral centers (RS-RS, SR-SR, RS-SR, SR-RS). It was found that RS-RS is the most potent at inducing the compaction of large DNA molecule through a single-molecule observation in solution: the threshold concentration of RS-RS was one-fourth those of the other isomers. On the other hand, however, 1H NMR titrations showed that the binding potential of the pair of enantiomers RS-RS and SR-SR was two times greater than that of the other pair of enantiomers RS-SR and SR-RS. These facts clearly indicate that the ability to induce DNA compaction cannot be explained by simple electrostatic binding models. Such a characteristic effect on the higher-order structural changes in DNA were discussed in relation to the changes in the secondary structure as monitored by CD measurements and to the appearance of a unique morphology with mini-toroid clusters as visualized by electron microscopy. These effects of chiral polyamine analogues on DNA compaction may provide new arrows for the design of effective anticancer agents.

Paper Number: 0007

COMMISSIONING AND QUALITY ASSURANCE OF CALYPSO 4D TARGET LOCALIZATION SYSTEM IN LINEAR ACCELERATOR FACILITY

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PURPOSE:

The purpose of this presentation is to describe the results of commissioning measurements carried out on the 4D Target localization system to verify the manufacturer specifications and also to evolve a QA procedure which can be used to test its performance routinely.

METHODS:

4D Target localization system (Calypso system) is equipped with Beacon Transponders, Console, Electromagnetic Array, Optical System andTracking Station . The QA consists a series of tests (checking the calibration , Camera Calibration with L-frame fixture and T-frame fixture, Fixture targets test, Localization and Tracking).

RESULTS:

In system accuracy QA the detected positions of the fixture with respect to calibrated calypso system isocenter in lateral, longitudinal and in vertical directions were -0.12 cm,-0.15 cm and 0.00 cm respectively. The isocenter offset was 0.02cm.

Camera Calibration with L-frame fixture was passed in all the cases by proper positioning of L-Frame and exposing optical targets when four light sources were detected.

T-Frame calibration was passing with test results of T-frame average, 3D residual, standard deviation and absolute deviation were 0.15mm, 0.28mm and 0.03 mm respectively.

The offset that was obtained by isocenter fixture was -0.02cm, 0.02cm, 0.01cm and 0.03cm .In localization and tracking test Setup accuracy, tracking accuracy and Precision were measured less than 0.05cm, 0.05cm and 0.07cm.

CONCLUSION:

The system is capable of localizing and also perfect tracking. Some of these tests should perform on daily basis and some are monthly. These tests also proved that Calypso system is impeccably suitable for tracking or 4D Target localization.

Paper Number: 0319

COMMISSIONING AND ROUTINE TESTING OF DIGITAL AEC SYSTEMS

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Correct setup of AEC device upon installation of any x-ray room is important, however given the range of manufacturers and different detector composition along with the nature of installations (fixed, wireless, table and vertical) and use of detectors and rooms within a Trust, there can be difficulty in ensuring that the dose to the patient is ALARP while image quality is adequate.

This submission details the method that improves upon what is detailed in IPEM report 32 (vii) and presents the results together with an achievable dose curve which can be used as guidance along with image quality assessment.

Using a 1mmCu phantom at the tube head, the DAK is measured on the table with AEC on and then corrected to the surface of the detector for distance, effects of chamber and effects of grid, if not removable (DAKcorr), across the range of kV settings.

The DAKcorr for each kV from 35 systems has been pooled to establish a ‘typical' curve for which it is expected a new digital AEC system should be able to achieve. If a new system has a curve that is higher than 2σ at any commonly used kV, it is recommended that the engineer adjust the system for a DAK closer to the typical curve. Once the curve has been established, image quality should be checked with an anthropomorphic phantom by appropriate experts.

Paper Number: 0277

COMPARING OF DOSE PROFILES OF "LİGHTSPEEDTM RT" CT UNITE BY TLD

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AIM

Dose profiles of LightSpeed-RT CT were obtained by using the TLDs and dose values was compared.

MATERIALS AND METHODS

Twenty LiF:Mg(Ti) TLDs were lined into a rod-shaped carrier with suitable interval along 10cm. RADOS RE-2000RT reader was used. All dose measurements were performed in-air along rotation axis. To investigate the effect of energy, FOV and slice thickness (10 or 4x2.5 mm) on dose profiles were performed. The peak, %10 peak width and FWHM values were obtained. The area under profile was considered as CTDI value, for comparison the peak by FWHM value were calculated.

RESULTS

For energy dose dependence 80 kV helical exam 1cm slice thickness on the sFOV was selected as reference. As the kV increased to 140 the peak value and peak by FWHM value increased three times. FWHM and %10 peak width values were increased to 4.08+0.5 and 5.9+0.2mm respectively. For FOV dependence in helical and axial the 120 kV-200mA 1cm slice thickness exams were evaluated. The peak value and peak by FWHM value were larger on the sFOV exams. The helical and axial exams with120kV-200mA at sFOV were selected for comparing dose profiles of 1x10mm and 4x2.5mm slice thickness. The ratios of peak values in axial and helical exams were 1.1 and 1.15 but the ratios of the peak by FWHM values were 1.1 and 0.53 respectively.

CONCLUSION

TLD allows a more detailed evaluation on dose profile. Increasing of dose based on the slice thickness, high energy and sFOV parameters was found to be effective.

Paper Number: 0348

COMPARISON BETWEEN VMAT CT PLANNING AND SEGMENTED MRI IMAGES WITH ASSIGNED BULK DENSITY: A DOSIMETRIC STUDY FOR INTACT PROSTATE PATIENTS.

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BACKGROUND + OBJECTIVES

MR based radiotherapy is being extensively investigated due to the superior soft tissue contrast which is enhanced by using appropriate pulse sequences. Current MR Systems ensure that there is no loss of geometric accuracy and distortion however the lack of electron density information remains a problem for radiotherapy planning on MR Images.

This is a retrospective study using VMAT planning on segmented MR images with bulk density assigned for intact prostate patients.

MATERIALS/METHODS

MR images for 10 patients were acquired on GE Optima MRI scanner and segmented, the bulk density was assigned as per ICRU 46 to the contours . VMAT plans were created and optimized on the Varian Eclipse TPS using the AAA algorithm on the Pseudo CT/ MR study data. The resulting dose distributions were assessed for PTV coverage and OAR constraints to obtain clinically valid plans.

The resulting dose distributions were assessed by re calculating the MR optimized plans on the original CT data sets keeping the plan parameters the same.

The optimized results for TCP and NTCP data will be presented for PTVs and OARs together with DVH comparisons. Quantitative analysis of the differences in dose distribution using Gamma Index Analysis will be performed using SunNuclear Arccheck and all results will be presented.

RESULTS

A detailed data analysis of the 10 Patients results will be presented.

CONCLUSION

Initial assessment of the data indicates VMAT planning on MR only images with appropriately assigned bulk density information is clinically acceptable for intact prostate cases.

Paper Number: 0105

COMPARISON CALCULATOR OF CVOL AND DLP WITH CT DOSIMETRY OBTAINED FROM DICOM IMAGES OF ABDOMEN

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Radiology departments in Colombia consider the CT reports as a reference of the patient doses received in the procedure. This information can be considered reliable if an appropriate CT dosimetry is carried out properly. These calculations are based on the Cw , CTvol and DLP. These magnitudes depend primarily on the characteristics of the CT scanner and then to the protocol applied in 100 CT exams. In many Latinamerica countries the dose estimate is based on the register of all scan parameters obtained during the exam, which consume time and interfere in the procedure. The data obtained from DICOM header retrospectively is easily but not always report all indispensable information or the information is totally guarantee. The survey was carried out in the Instituto Nacional de Câncer (INCA/Brazil) and in the Instituto Nacional de Cancerología (INC/Colombia). The DICOM images of abdomen area were taken from a Philips Brillance 6 and in the GE BrightSpeedElite16 and SiemensSomatonSensation16. In the DICOM header of this images can be extracted exposition factors per slides. Therefore, Cvol and DLP values are calculated by Python software and compared with beam dosimetry, technical factors and console display. The estimated Cvol and DLP values were in accordance with the DICOM header and console display. The perceptual differences between these values were 8%. This calculate of doses from DICOM header and by Python Software is a useful and easy tool allow determinate and report the patients radiation doses in each patient faster and immediately or retrospectively after of scan.

Paper Number: 0382

COMPARISON OF ALGORITHMS FOR DETECTION AND QUANTIFICATION OF HEPATOCELLULAR CARCINOMA

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Evaluation of hepatocellular carcinoma (HCC) is based at mRecist criteria and involves measurement of the maximum contrasted diameter of the lesion. Milan criteria is used to identify patients who are suitable for liver transplantation. To meet this criteria, the maximum diameter of one tumor should be <5 cm, or the maximum diameter of each one of three tumors should be <3 cm. This study compared four types of tumor localization and quantification to measure contrasted area and maximum diameter of the contrasted lesion. Wavelets were used for filtering a pre located region of the liver manually selected, fuzzy clustering methods and manual thresholding effectiveness were evaluated. Algorithms results were compared against a ground truth area originated by three radiologists in 62 images of HCC.Four different methodologies (Manual Thresholding, Fuzzy Clustering, Wavelet+Manual Thresholding and Wavelet+Fuzzy Clustering) were compared. Wavelet combined with fuzzy clustering methods showed better agreement with a sensibility of 85% and specificity of 96% and no human subjectivity in its process. Manual thresholding implies in the human determination of the threhold and it results showed lower sensibility (71%) but better specificity (99%). This study showed significant results for HCC evaluation. This is an important subject specially for patients with tumors in the non transplantable threshold regions. Area estimation based on maximum diameter, as is done by radiologists, showed significant errors for tumors larger than 5 cm but were accurate for small-sized tumors. Therefore, traditional methods for measuring the lesion diameter should be complemented with new measurement methods.

Paper Number: 0189

COMPARISON OF AN EXTRADIN A1SL CHAMBER AND A SCANDITRONIX STEREOTACTIC FIELD DIODE FOR SMALL FIELDS

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Beam profiles are commonly measured with small ionisation chambers such as the Extradin A1SL ionisation chamber, with a 4.15mm sensitive diameter. IPEM report 103 (IPEM 2010) recommends using smaller detectors, especially for narrow fields. We have measured profiles on a 1cm wide beam from a TomoTherapy unit, using both the A1SL and a Scanditronix Stereotactic Field Diode (SFD) with a sensitive diameter of 0.6mm.

Profiles were taken in longitudinal and transverse planes for several field lengths ranging from 6.25 mm (1 MLC open) to 400 mm (all MLCs open). The profiles acquired at depth in water, were corrected to 85 cm FSD. The longitudinal full width half maximum (FWHM) was 10.2 - 10.6 using the SFD and 10.6 - 10.8 mm using the A1SL. In the transverse direction, the FWHM was 5.2 - 6.2 mm with the SFD but 5.9 - 6.6 mm with the A1SL per 6.25 mm leaf at 85 cm FSD. The results suggest the SFD is accurate enough to observe the tongue and groove effect, whereas the A1SL leads to overestimation of the field size, obscuring this effect.

Convolving the SFD profiles with a point spread function to account for the diameter of the A1SL, we get profiles that agree closely with the A1SL measurements; this confirms that the size of the A1SL leads to an overestimate of width for small fields.

The SFD data will be used as input to CheckTomo (Thomas et al Med. Phys. 39 160-167, 2012) an independent dose calculation program for TomoTherapy.

Paper Number: 0102

COMPARISON OF DIFFERENT DOSIMETRY METHODS FOR WIDE CONE BEAM CT

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The aim of the present study is to compare and verify different dosimetry methods for wide cone beam CT in terms of CTDIfree-in-air and CTDIphantom. The study was performed with Aquilion ONE 320-row detector CT (Toshiba Medical Systems). The method suggested in the IAEA Human Health Reports No. 5 was tested first. Free in air measurements were performed with a standard 100 mm CT pencil ion chamber, stepped through the X-ray beam, along the z-axis, at intervals equal to its sensitive length. Two cases were studied – with integration length of 200 mm, and with integration length of 300 mm. Phantom measurements were performed with a standard PMMA dosimetry phantom. Measurements were performed also with a twice-longer phantom and two 100 mm chambers positioned and fixed against each other, forming a detection length of 200 mm. Free in air and phantom measurements were performed to study the real dose profiles along z-axes using TLD and gafchromic dosimeteres. Fabricated PMMA tubes of total length of 300 mm containing LiF detectors and narrow strips of gafchromic film screwed in cylindrical shape were used. The pilot results indicated that CTDIfree-in-air measured with an integration length of 300 mm was about three times higher than the standard CTDI measurement with a100 mm CT ion chamber. Complete results and conclusions will be presented.

Paper Number: 0097

COMPARISON OF METHODS FOR PATIENT DOSE MEASUREMENT IN DENTAL RADIOGRAPHY

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The aim of the present study is to compare different methods used for patient dosimetry in intraoral and panoramic dental radiography, and to choose the most practical one to performed national patient dose survey and to elaborate DRLs. Methods described in the IAEA TRS 457 “Dosimetry in Diagnostic Radiology: International Code of Practice” were applied: for intraoral radiography the measurements of Incident air kerma were performed with multi-purpose detector of X-ray multimeter Barracuda (RTI Electronics) and for panoramic projection air kerma-length product was measured with CT chamber calibrated. The size of the radiation field at the end of the spacer cone was measured using Ready pack film and Gafchromic film, processed with rendering software, as well as with a CR cassette. For the panoramic projection the beam size at the second collimator was also measured with Ready pack and Gafchromic films. For both projections air kerma-area product, PKA, was calculated from measured parameters, as well as directly measured with Diamentor E2 with square and circular Diamentor chambers (PTW, Freiburg). The pilot measurements performed on one intraoral and one panoramic unit demonstrated up to 14% higher values of PKA calculated compared to the directly measured that can be attributed to the higher uncertainty due to the field size measurements. Complete set of ongoing measurements and analysis will be presented, as well as findings and conclusions.

Paper Number: 0101

COMPARISON OF PATIENT EXPOSURES ON MOBILE FLUOROSCOPY SYSTEMS

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The aim of this paper is to compare the performance of C-arm fluoroscopy systems used for surgical procedures in terms of entrance surface air kerma (ESAK) rate. The measurements were performed during regular quality control (QC). Thirteen C-arm systems were included, six of them of the same model, as well as one biplane system. ESAK rate was measured on the entrance surface of 20 cm water phantom under normal operating conditions, with focus to skin distance (FSD) varying from 52 to 90 cm. For comparison purposes the ESAK rate was normalized to 70 cm FSD. Measured ESAK rate for normal dose rate mode without magnification was between 12.2 and 40.5 mGy/min and the normalized values were between 10.5 and 24.6 mGy/min. None of the values exceeded the limits of 50 mGy/min adopted in the country. ESAK rate for first magnification was from 13.7 to 60.1 mGy/min, and the normalized values were from 14.1 to 36.4 mGy/min. Large variations in normalized ESAK rate values up to 51 % were observed even between the systems of the same model. This can be due to some extent to the fact that some of the measurements were performed with patient table positioned between the X-ray tube and the image intensifier and the others - without a table. The approach to measure without a table when possible was adopted during QC, aimed to unify the measurement conditions. Further standardisation of the measurement procedure is suggested.

Paper Number: 0212

COMPARISON OF THE RADIATION OUTPUT OF A STANDARD C-ARM AND MINI C-ARM: EVALUATING NEW EQUIPMENT FOR EXTREMITY PROCEDURES AT A PEDIATRIC INSTITUTE

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INTRODUCTION

Our pediatric hospital strives to keep radiation exposure ALARA to mitigate stochastic effects in the pediatric population. This applies to extremity procedures, where up to 28% of total active bone marrow is present in a pediatric patient. Recently, our hospital considered the purchase of a mini C-arm, which was promoted as a convenient low-cost, low-dose modality.

This work compares the radiation output of the current full-sized C-arm (FC) with a mini C-arm (MC), with emphasis placed on examining effects of different control parameters on the radiation output.

METHODS

Cadaveric hand bones, encased in acrylic, were used to simulate the clinical anatomy. Measures of entrance dose rate and scatter rate were made on both a FC and MC under automatic exposure control using a variety of operating conditions (continuous, pulsed, low-dose, magnification, etc...).

RESULTS

Entrance dose rates ranged from 0.08 to 1.85 mGy/min and 0.72 to 2.15 mGy/min, for the FC and MC, respectively. Scatter rates at 30 cm from the phantom ranged from 10 to 136 uSv/h and 18 to 124 uSv/h, for the FC and MC, respectively. Entrance dose and scatter were highly dependent on the operating conditions used on both units.

CONCLUSIONS

Our site declined use of the MC due to its higher radiation output. The main drawback of the MC was its lack of a pulsed fluoroscopy mode, which contributed to large dose savings on the FC. This work illustrates the need for imaging centers to evaluate equipment performance and radiation output when deploying new technology.

Paper Number: 0383

COMPUTED ALGORITHM FOR BREAST DENSITY CLASSIFICATION

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OBJECTIVES

The purpose of this study is to describe a computed estimation of mammographic density method based on a step wedge phantom and a correlation factor with the breast density.

METHODOLOGY

A PVC step wedge phantom that simulates the mammographic density of a breast with 5,0 cm of thickness composed of 50% fat and 50% glandular tissue was developed. Fitting wedge histogram with gaussians was used to calibrate the density of the analyzed breasts in a way that we could quantify the amount of fat and glandular tissue in the mammogram.

RESULTS

The algorithm was applied to mammograms from 70 women aged between 30 and 77 years and well classified the density from all the radiographies. Average breast with and without radiological findings are composed of % and % of dense tissue, respectively.

CONCLUSION

Finally, the algorithm presented here differentiate well the tissues in the breast and can be used in a future assessment of the risk factor of the dense breast as an quantitative and more reproducible method to analyze the density using a mammogram as input.

Paper Number: 0073

CONCEPT OF A COMPACT ROTATING GANTRY FOR LASER ACCELERATION BASED PROTON THERAPY

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For the wide spread of ion beam therapy with its physical and radiobiological advantages for cancer treatment, it is essential to reduce the size and costs of these facilities (accelerator and associated gantry). The particle acceleration based on high intensity laser pulses is an attractive alternative to fullfill these requirements in future.

In contrast to conventional accelerators, more compact laser based accelerators deliver short pulses with high particle numbers (1010 to 1012) but with low repetition rate (few Hz) and have high divergencies (15 degrees opening angle) and broad energy spectra. For such beams we designed a gantry system with efficient energy selection and particle capture based on linear beam transport matrix formalism and simulations to establish transport efficiencies and energy spectra.

The developed 360 degrees rotatable isocentric gantry concept for laser based proton therapy uses a solenoid, four 45 degrees dipole and nine quadrupole magnets. It allows to select individually for every pulse both the proton mean energy and the energy width. The pulsed nature of laser generated beams allows for using pulsed power magnets, which are lighter in weight and can achieve higher magnetic fields compared with conventional iron-core magnets. Thus enabling a gantry design with 3 m length and 2 m radius, which is 2-3 times more compact than conventional gantries. The functionality of a pulsed solenoid was already proven in laser acceleration experiments. The compactness of the gantry is one important part of possible savings by a laser based compared to conventional ion therapy systems.

Paper Number: 0059

CONSIDERATION OF ACCURACY OF DYNAMIC MYOCARDIAL PERFUSION 201-TL SPECT IN COMPARISON TO CONVENTIONAL IMAGING

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Dynamic SPECT imaging provides both kinetic and perfusion information for evaluation of CAD.

The objective was to evaluate accuracy of D-SPECT methodology in myocardial perfusion assessment in comparison to conventional method.

The TACs of myocardium, blood pools and body were calculated. Simulations were performed for normal organs utilizing NCAT Phantom, including dual-head gamma camera via SIMIND simulator. Thirthy-two second acquisition time-frames were used to track these dynamic changes. Different summations of six time-frames of dynamic imaging were performed to create each dataset, which were also compared to a single static dataset with consistent projections as reference. Also, the effect of FBP, Wallis, OSEM and FLASH-3D algorithms and delay times after injection (0:32:448 sec) were assessed. Twenty-segment analysis of myocardial perfusion percent (MPP) was performed by QPS . Dynamic data were successfully acquired using optimal serial scanning protocol as extracted in simulation studies. Conventional imaging was subsequently performed.

According to QPS computation, for different summations of time-frames MPP, mean values in basal and mid regions in case of D-SPECT revealed 14.4% and 7.3% increases with maximum changes in basal anterior, ,while distal and apical segments showed 4.3% and 4.5% decrease.Specifically, imaging with 3 to 6 time-frames yielded more accurate quantitative values related to usage of less time-frames (r=0.957). Wallis showed higher MPP (r=0.996). Summing procedure that produced the best correlation were 128 to 224 sec post-injection (r=0.982 to r=0.988).

D-SPECT may provide high accuracy functional information for detection of CAD, and could be used to extract kinetic parameters of interest.

Paper Number: 0274

CONTRIBUTION OF IN VIVO DOSE MEASUREMENT TO THE INTENSITY MODULATED RADIOTHERAPY TECHNIQUEIN THE TREATMENT OF NASOPHARYNGEAL CANCER

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PURPOSE
The contribution of in-vivo dose measurement of organs at risk by TLD-LiF100 and IDF-thin IBA diode during IMRT in treatment of nasopharyngeal cancer was studied.

METHODS
Appropriate nasopharyngeal carcinoma patient's target and organs at risk contours managed for IMRT planning were fusion on CT images of rando phantom. For PTVI-II-III the equally angel nine-fields IMRT plans were designed using 6MV energy with 200cGy/fr to 50, 60 and 70Gy respectively. The dose measurements for the quality control evaluation of IMRT plans were done. Nasal-cavity location was selected for PTVs. The selected locations for parotid and thyroid were oral-cavity and ear-cavity, and on the skin. Each dosimeter was selected and located on measurement region. In-vivo dose measurements were performed and repeated, the dose for PTV and OARs compared with TPS.

RESULTS
The percentage dose differences between TPS and TLD for nasal-cavity location where represented the patient's PTV in three phases were %0.6, %0.77 and %1.63 respectively. %dose differences were higher by diode that may be reduced by using suitable fixation. By diode the %dose differences in the ear and oral cavity that recommended locations for parotid were %1.7 and %8.7 in phase-I, %1.5 and %6.7 in phase-II respectively. The calculated and measured dose of thyroid in phase-II (5.8cGy) and phase-III (2cGy) was compatible. In phase-I dose difference were obtained 39%.

CONCLUSION
QA of IMRT nasopharyngeal cancer patients dose by in-vivo dosimetry was determined as an ideal and reliable dose control method in terms of PTV and OARs by TLD or diode.

Paper Number: 0261

CT DOSE REDUCTION IN PEDIATRICS: A NEW MODEL BASED APPROACH

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PURPOSE

Several recent publications have raised concerns about the increased use of Computed Tomography (CT). This is especially true for pediatric patients, as children are more sensitive to ionizing radiation. Therefore, it is crucial to optimize examination protocols and procedures, especially in this patient group. This optimization process is difficult and complex due to the complexity of the acquisition parameters, starting with the individual patient characteristics, taking into account the available scanner and the required diagnostic image quality.

OBJECTIVE

To support the optimization process, we propose a new model-based approach using Multi-Objective Optimization Algorithms (MOOA).

METHODOLOGY

We believe that MOOA like the Multi Objective Genetics Algorithm (MOGA), Simulated Annealing (SA) or Ant Colony Optimization Algorithm (ACOA), used in other domains, like in industry, in applied mathematics or neurology, are particularly suitable for supporting this optimization process. During this talk, a review of available dose-saving options (technological, organizational and parametrical) will be presented. Out of these available options, we will propose a suitable MOOA model.

CONCLUSION

We suggest to incorporate the MOOA method into the CT optimization process. This will provide interesting, optimized examination protocol parameters that can further be investigated and validated.

Paper Number: **0126**

CURRENT PRACTICE FOR PATIENT DOSIMETRY IN NHS TAYSIDE

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Patient dose audits are routinely performed in the UK. This poster will review some of the methods used in NHS Tayside to ensure audits are accurate and useful without significant extra work.

In order to carry out useful patient dose audits it is necessary to ensure data is sufficiently accurate. In NHS Tayside we have access to stats from the Radiology Information System (RIS). This provides large amounts of data with variable accuracy recorded for all examinations.

Appropriate visualisation of data is necessary to sanitise data. We will demonstrate some simple techniques provide a great improvement in data quality for minimal effort.

For radiographic data plotting relative exposure (kVp2×mAs) against DAP is a simple way of identifying typos and other spurious entries. By calculating the ratio of this check value over DAP, data can be rapidly sorted to identify outliers.

Plotting relative exposure vs. DAP can also help identify multiple examinations under the same RIS codes; e.g. conventional AP Abdomen radiographs combined with coned Bladder radiographs. Histograms of DAP and Box Plots of DAP over time can also reveal further information.

In all cases, analysis of data needs context that can only be provided by good relations with clinical (particularly radiographic) colleagues.

Examples presented include:

Discrepancies between rooms explicable by clinical workload.

Local technique changes resulting in reduced doses. These are being implemented elsewhere in NHS Tayside.

Failures in training, technique and clinical practice highlighted by audit.

Paper Number: **0372**

DELIVERING RAPIDARC® FOR PROSTATE CANCER

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PURPOSE

The Beatson West of Scotland Cancer Centre is the largest department in Scotland treating over 6,500 patients each year. The Centre sought to extend the availability of inverse planned, dynamic treatments for all prostate patients. High patient throughput on existing accelerators is often perceived as a barrier to increasing clinical access to IMRT. A decision was taken to adopt Varian RapidArc® technology as the primary method of achieving increased IMRT capacity.

METHOD

A retrospective study was performed to compare RapidArc® with dMLC IMRT planning. The objective of this study was the development of a class solution. A second retrospective study was performed to compare conventional RapidArcÔ planning with TrueBeamTM Flattening Filter Free (FFF) mode.

RESULTS

The retrospective planning study show that RapidArc® offered plans of superior quality with reference to both target coverage and organ at risk sparing on all occasions, with treatment times reducing to 60 seconds compared to approximately 140 second for dMLC IMRT. Results of the second study demonstrated plans of a comparable or improved standard with FFF, with treatment delivery times reducing to 40 seconds.

CONCLUSION

Both RapidArc® and FFF mode gives improved conformality with a significant reduction in treatment time. In a 10 month period from May 2012, approximately 300 patients have received RapidArc®. The 3D conformal planning practice has been withdrawn from routine clinical use.

Paper Number: 0095

DESIGN AND EVALUATION OF AN IGRT SOFTWARE FOR DAILY TARGET ALIGNMENT

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PURPOSE

To design and evaluate an IGRT software for organ motions estimation during the course of radiotherapy.

METHODS AND MATERIALS

A fiducial marker technique, originally developed in the pre-conformal radiotherapy era, has been used with our homemade software. Fiducial markers are implanted in the organs and orthogonal portals are performed daily before the treatment. The software does 2D-2D matching based on the fiducial markers for these orthogonal portals and calculates shifts (mm) in the superior-inferior (SI), left-right (LR) & anterior-posterior (AP) dimensions in comparison to the reference digitally reconstructed radiographs (DRR). The interfraction motion in any direction is then calculated by using shifts in any dimension. QA of this software has been performed using seed embedded Styrofoam phantom. About 20 known shifts in different dimensions were stated for imaging and compared with the results calculated from software.

RESULTS

An average difference of about ≈0.1mm has been calculated regarding the precision of this software. Shifts optimization obtained from this simplified IGRT software has been used to rescale/shift the treatment position which allows minimizing the variation interfraction organ motion.

CONCLUSION

Assessment of this new software tool has been successfully tested for delivering IGRT to reduce the interfraction motion.

Paper Number: **0011**

DESIGN OF TRUNK AND PELVIC PHANTOM FOR VERIFICATION OF A TREATMENT PLANNING SYSTEM ALGORITHM

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A phantom for use in radiotherapy treatment planning of human trunk and pelvic anatomical region has been designed with six hollows for inserting materials mimicking different biological tissues and the ionization chamber. For the trunk, pure glycerol was used for muscle, 75% to 25% glycerol-water was used for liver, Carboxyl-Methyl-Cellulose (CMC) was used for lungs, 50% to 50% glycerol-water was used for adipose, and Sodium Laureth Sulphate was used for kidney. For the pelvic, the prostrate, bladder, adipose, muscle and rectum had compositions of Carbon, Oxygen, Hydrogen and magnesium while the constituent of bone for both regions were Carbon, Calcium, Oxygen, Hydrogen and Magnesium. The phantom was scanned with Hi-Speed CT-scanner and the images were transferred to a precise plan treatment planning system. Several treatment plans were made using the full area integration algorithm in the treatment planning system. Measurements of absorbed dose were conducted using 6 MV photon beams from the ELEKTA-Precise clinical linear accelerator. The phantom results were compared to those from a solid water phantom used for routine clinical measurements. The maximum standard deviations for the trunk and pelvis were +3% and 4% respectively. The maximum standard deviations for the trunk and pelvis with six beams and bone inhomogeneity were 3% and +2% respectively. The maximum deviation for the trunk with small fields was +3%. The deviation between the phantom measurements and those of the solid water was 1.3 %. All deviations were within acceptable limits; hence the phantom can be used for routine verification measurements.

Paper Number: 0229

DETECTION OF THE GOLDANCHOR™ MARKERS IMPLANTED IN THE LIVER BY THE CYBERKNIFE SYSTEM DURING THE REAL-TIME IMAGE-GUIDED ROBOTIC RADIOTHERAPY OF PATIENTS WITH LIVER METASTASES.

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BACKGROUND
The use of fiducial markers allows the precise location of the tumor and thus, the dose escalation without increasing the risk of side effects. The aim of this study was to compare the detection of markers implanted amounts in the liver and the quantity makers by the CyberKnife system located on the therapeutic machine

MATERIAL
The analysis was based on the results of irradiation of 19 patients diagnosed with metastasis cancer to the liver. Total implanted 57 gold markers. All markers were detected on X-ray images by the panel and they were determined as active treatment. 117 images were used to retrospective analysis.

RESULTS
In 3 patients (15.8%) who were implanted gold markers, the system detected all markers in each fraction. In 16 patients (84.2%), the system detected the same number of markers in all fractions. In 3 patients, while one of the three fractions of treatment, the system detected one marker less compared to the other two fractions. In 79.4%, 13.7%, 4.3% and 2.6% of cases the CyberKnife system detected: 2, 1, 3 and 4 markers. In 3 patients (15.8%) the system detects at least three markers. There was a case where the system is not detected a single marker.

CONCLUSIONS
The analysis showed that the detection of gold markers in different fractions of radiotherapy in the same patient appears to be repeatable. Therefore, gold markers seem to be an effective tool for the precise location of the position of the irradiated volume during the treatment.

Paper Number: 0371

DETERMINATION OF THE ACTUAL SIZE OF SMALL PHANTOMS UTILIZING GAMMA CAMERA WITH PINHOLE COLLIMATOR

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INTRODUCTION

Pinhole gamma camera produces magnified or minified images depending on object-to-pinhole distance "b" and collimator depth "t". Estimating actual size of small organs, such as Thyroid facilitates determination of I131 radioactive therapy dose.

MATERIALS AND METHODS

Gamma camera equipped with pinhole collimator (t=19cm, aperture diameter 0.5cm, aperture depth a=2cm) was utilized. Tc99m scans were obtained at various distances, with and without zoom. Multi point's radioactive source and picker's thyroid phantoms were utilized as objects. Images of one dimension (length) and two dimensions (area) objects were obtained and corresponding lengths and areas determined. From box camera geometry, MX=Kt/(b+a), where MX is one dimension image magnification and K is gamma camera factor. Object distance which corresponds to actual size image (MX =1) is given by bo =Kt-a. For two dimensions, MA =(Kt/ (b+a))2.

RESULTS

Linear relations were obtained between 1/MX and 1/√MA versus b for the multi source and thyroid phantoms (R2 ~ 0.98). Gamma camera with 1.5 zoom produced images which were 1.5 and 2.25 times larger for one and two dimensions respectively. Discussion: Image size is controlled by two factors; distance from object-to-pinhole; and Gamma camera zoom. Actual image size with and without 1.5 zoom were obtained at b ~19.2cm and ~11.5cm respectively; a factor close to 1.5. Two dimensions images with zoom must be divided by (zoom) 2 to estimate object's actual size.

CONCLUSION

Knowing the physical parameters of pinhole collimator and Gamma camera facilitates the estimation of actual size of small organs.

Paper Number: 0246

DEVELOPMENT OF A 3D-PRINTED SUB-RESOLUTION SANDWICH PHANTOM FOR THE SIMULATION OF HMPAO SPECT IMAGES

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BACKGROUND

Dementia is routinely assessed using Statistical Parametric Mapping (SPM) to compare HMPAO SPECT scans to a database of normal subjects. These databases are scanner specific, leading to variations in SPM presentation between hospitals and threatening service continuity when replacing gamma cameras.

Phantoms using the sub-resolution sandwich method (SSM) allow the simulation of realistic uptake patterns by placing 99Tcm printed onto paper between layers of tissue equivalent material.

Following the receipt of an IPEM Innovation and Research Award, we have investigated the feasibility of using a 3D printer to create realistic, head shaped, tissue equivalent layers in an SSM phantom.

MATERIALS AND METHODS

BrainWeb MRI segmentation maps were used to create a volume suitable for 3D printing. Individual 4mm slices from the volume were printed using a RepRap Mendel 3D printer using standard plastic feedstock of known attenuation. A brain pattern template from the same MRI data was printed onto paper using ink mixed with 99Tcm pertechnetate. Lesions were simulated in the template by reducing the printed intensity.

RESULTS

Unlike elliptical SSM phantoms, the realistic shape meant that standard clinical software could be used to reconstruct phantom data. All lesions were clearly visible in the reconstructed slices.

Conclusions: We have created a sub-resolution sandwich method phantom that is realistically head shaped. This has been demonstrated to significantly improve the usefulness of this type of phantom. The next stage of this work is to create a skull within the phantom from a bone equivalent material to better simulate absorption and scatter.

Paper Number: 0265

DEVELOPMENT OF A DIFFERENTIAL PRESSURE MODULE FOR MEASUREMENT OF FLOW IN A BLOOD CIRCUIT.

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INTRODUCTION

A prototype medical device under development requires measurement of pressure and flow in a blood circuit. This project aimed to develop an electronic box to investigate the principle of using two pressure transducers (required for self-checking of pressure measurement) with a small resistance between them to provide flow measurement.

METHODOLOGY

Differential pressure was measured by designing a circuit that used an instrumentation amplifier for each of the two pressure channels. The resulting signals were then passed into a differential amplifier. The offset and gain of the differential pressure signal was adjustable with multi-turn potentiometers allowing calibration.

An air-filled circuit and primary-standard manometer were used to calibrate the pressure transducers and their ‘common-mode-rejection ratio'. The device was tested at ‘known' flow rates using a peristaltic pump and a gravity-driven circuit.

RESULTS

The device had a common-mode-rejection ratio of 44 dB, equivalent to 1.8 cmH2O for ± 600 cmH2O common-mode pressure. The peristaltic pump generated highly pulsatile flow and proved unsuitable for calibrating the system. The gravity-driven circuit provided steady flow. This established that the pressure-flow relationship is non-linear. Research is underway to establish the stability of the relationship and its suitability for providing flow measurement.

CONCLUSIONS

The method shows promise but the differential pressure-flow rate relationship is non linear. Adding a digital processor would correct the non-linear relationship, even if this was also a function of the common-mode pressure. The effect of temperature on measurements was not investigated but, if necessary, it may also be possible to compensate for this.

Paper Number: **0298**

DEVELOPMENT OF A METHODOLOGY FOR SCATTER REMOVAL IN MAMMOGRAPHY BASED ON A WIDE-BAND MONOCHROMATOR AND A PIXELLATED SPECTROSCOPIC DETECTOR

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We propose an alternative approach to the anti-scatter grid for scatter removal in mammography. This is based around the use of a broad-band monochromator and a pixellated spectroscopic detector.

The detector is a 1mm-thick, 80x80 CdTe array with a pixel pitch of 250 μm and with an energy resolution of 1.69 keV at 44 keV.

The monochromator, based on a Highly Oriented Pyrolytic Graphite (HOPG), provides X-rays with a bandwidth of 10% - 20%, allowing a good photon flux even from a conventional X-ray source.

Compton-scattered X-rays have lower energy than the incident X-rays; therefore, if the spectrum of the radiation incident on the detector is available, they can be removed using a windowing technique, essentially providing a scatter free image at a much lower dose than conventional mammography. The high energy-resolution of the detector allows optimum selection of the full-energy window, thus minimising the contribution of scatter to the final image.

We present the results from the characterisation of the system, with consideration on the dosimetric aspects and preliminary imaging data.

Paper Number: 0140

DEVELOPMENT OF A NEW HYBRID DYNAMIC TUMOR-TRACKING IRRADIATION TECHNIQUE USING VERO4DRT; PRELIMINARY STUDY

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PURPOSE
In the dynamic tumor-tracking irradiation (DTT) using Vero4DRT, the target position is continuously predicted; however, the prediction errors normally get much greater around the end-exhalation and end-inhalation phases. The purpose of this study was to propose a combinational technique of DTT and a gated irradiation (Hybrid DTT) by avoiding the respiratory phases with large prediction errors.

MATERIAL & METHOD
A QUASAR platform phantom with 2D dose profiler on was put on the couch. The QUASAR was driven along SI direction by seven sinusoidal patterns [Peak-to-peak (PP): ±10-20 mm, Time period (T): 2-8 s]. Its motion was measured by a laser displacement gauge. Next, a 4D model which predicts future tumor positions from the current position was created. The gated threshold was set to -10 mm because the prediction error by the 4D model in this study became much larger around the end-inhalation than around the end-exhalation. The dose profile was acquired during MV x-ray irradiation for a field of 5x5 cm2 in DTT and Hybrid DTT modes, respectively.

RESULT
The dose profile was shifted (< 2 mm) and FWHM of the dose profile became smaller than the predefined FWHM in both modes. However, the edge of the profile in the Hybrid DTT irradiation became sharper than in the DTT irradiation for the dose profile at (PP, T) = (±15 mm, 2-4s).

CONCLUSION
The preliminary result has demonstrated that Hybrid DTT irradiation technique has a possibility to improve the tracking accuracy by avoiding the respiratory phases with large prediction errors.

Paper Number: 0353

DEVELOPMENT OF PEDIATRIC PHANTOM CHEST EQUIVALENT

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The aim of this work is to develop a pediatric phantom chest equivalent for 1 to 5 years old patients. For this purpose we used a computational algorithm to quantify biological tissues (soft, bone and lung tissue) in examinations of computed tomography (CT). The computational algorithm developed on the Matlab® distinguishes and quantifies the biological tissue present on the mean free path of the X-ray beam in retrospective CT examinations. This process is performed by histogram analyzes of each CT slice followed by Gaussians fitting for each tissue at the anatomical region of interest. Preliminary results for the age group under study correspond to the measurements averages of 46 patients. The anterior-posterior diameter was 125.27 ± 2.95 mm, with 58.55 ± 7.76 mm of soft tissue, 9.81 ± 1.56 mm of bone tissue and 28.17 ± 5.4 mm of lung tissue. The biological tissue quantification can be simulated by 66.33 mm of lucite, 1.71 mm of aluminum and an air gap of 28.17 mm due to the similar characteristics of radiation absorption and scattering. The phantom developed in this study will be used in future research on optimization process of dose and image quality for pediatric radiological protocols.

Paper Number: 0360

DEVELOPMENT OF PEDIATRIC PHANTOM SKULL EQUIVALENT

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The radiographic optimization is a major concern in the pediatric radiology due to vulnerability of children to the effects of radiation exposure. The aim of this work is to develop and construct a homogeneous skull phantom for pediatric patients, aged between 1 to 5 years old, that will be used in optimization process of dose and image. Prior to construction of the homogeneous phantom it was necessary to classify and quantify the biological tissue present in the skull. In this procedure we used a computational algorithm developed on the Matlab® using retrospective Computed Tomography examinations. This algorithm is based on adjusting the Gaussian distribution of voxels of each CT slice. Each biological tissue type present in a histogram of the CT image is represented by a specific peak in which is possible to distinguish fat, bone and soft tissue. The homogeneous skull phantom was made of lucite and aluminum sheets which represent the attenuation characteristics similar to soft and bone tissues, respectively. Preliminary results correspond to the measurements averages of 45 patients. The anterior-posterior diameter was 145.74 ± 2.91 mm, with 82.43 ± 4.15 mm of soft tissue and 10.97 ± 1.25 mm of bone tissue. The biological tissue quantification can be simulated by 93.4 mm of lucite and 1.9 mm of aluminum due to the similar characteristics of radiation absorption and scattering. The pediatric phantom skull equivalent developed in this study will be used in future research on optimization process of dose and image quality for pediatric radiological protocols.

Paper Number: 0080

DEVELOPMENT OF PG-SPECT DETECTOR USING CRYSTAL SCINTILLATOR FOR ACCELERATOR-BASED BNCT AT PMRC

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An accelerator-based BNCT has started in construction of equipments at Tsukuba, Japan. In the BNCT, dose and dose distribution strongly depend on concentration of 10B compounds varying during treatment due to drug absorption, distribution, and elimination. Uncertainty of dose is, therefore, large unless the concentration is monitored as time advanced. A financially feasible and reasonable prompt-g-ray-SPECT (PG-SPECT) system is proposed to monitor prompt g-rays emitted from the prompt decay process in the reaction with reasonable resolution in energy and position. The PG-SPECT system is developed as one of the considerable g detector using a crystal scintillator viewed by a position sensitive photomultiplier tube (ps-PMT) and followed by readout electronics system. The system consists of 4x4 g-detector units using CsI scintillator as a prototype, which is eventually replaced later to higher performance crystal scintillator; CeBr3 or LaBr3. The 4x4 g-detector units are followed by 4x4 Compton-g-ray-veto counters using BGO scintillator, and their readout electronics system. The readout electronics system is originally developed in collaboration with TechnoAP Co. to measure g's energy and its incident position using chained-register technique (CRT), which reduces the number of channels from 16x16 to 2x2. Several types of scintillator; CsI, LaBr3, CeBr3, are examined in performance. Energy resolution is close to the nominal value of each scintillator while correctable-non-linearity is observed in position determination due to CRT. This system would be useful to improve uncertainty in dose and dose distribution in the BNCT.

Paper Number: 0252

DIFFUSION AND DYNAMIC CONTRAST ENHANCED MRI FOR LESION DETECTION AND CHARACTERISATION IN MALES WITH DIAGNOSED PROSTATE CANCER - PILOT STUDY.

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Prostate cancer is the most common male cancer in the UK. Prostate Specific Antigen (PSA) can be unreliable and provide inaccurate results. Biopsies can identify disease, but are invasive and frequently anatomically imprecise. This pilot study considered the relationship between multiparametric MRI parameters and biopsy results for patients with prostate cancer.

Fifteen patients with biopsy-proven prostate cancer underwent an MRI examination on a 3.0T Siemens Trio, including dynamic contrast-enhanced (DCE) and diffusion-weighted imaging. The apparent diffusion coefficient (ADC, b=50/400/1000 mm2/sec), time-intensity parameters (wash-in gradient, maximal enhancement, time-to-peak, wash-out gradient) and pharmacokinetic modelling parameters (ktrans, ve, kep, initial area under the Gadolinium curve (iAUGC)) were measured in a central slice of each lesion as identified by a Radiologist.

Twenty-four lesions were identified with Gleason scores (GS) of 7, 8 and 9. Mean PSA was 11.2 ng/ml (4.0-24.5 ng/ml), and modal GS=8. A weak positive correlation between PSA and GS was identified (R2=0.02), and ADC values were consistent with those reported in the literature (mean=0.839±0.069 mm2/sec).

A one-way ANOVA revealed significant differences ($p<0.05$) for ve, kep, maximal enhancement and wash-in gradient between the three GS groups. Post-hoc analysis showed significant differences between high (GS=9) and low-risk (GS=7) groups for wash-in gradient and maximal enhancement; and high and intermediate risk (GS=8) for ve, kep and maximal enhancement.

The preliminary results show that DCE parameters may be useful in differentiating between low, intermediate and high GS, which could be the basis for an image-based diagnostic and staging tool, prior to biopsy results being available.

Paper Number: 0395

DIRECT IN VIVO VERIFICATION OF IMRT DELIVERY USING A 2D TRANSMISSION DETECTOR, WITHOUT REQURING REFERENCE TO PRE-TREATMENT MEASUREMENTS OR ADDITIONAL PRE-TREATMENT LINAC TIME.

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The DAVID is an optically-transparent, 2-D transmission-style detector comprising two Perspex sheets, enclosing a vented air gap containing collection wires. These are aligned with individual MLC leaf pairs and in the leaf movement direction. Each wire is held at a potentialand its signal is proportional to the radiation fluence through its associated leaf pair; plus perspex scatter from adjacent leaf apertures. For standard in-vivo use, its signals are referenced to baseline values recorded at pre-treatment verification. However a new approach is suggested for direct in-vivo verification, based on independent check-software information to predict DAVID signals, as reference for the subsequent on-treatment measurements. This approach can identify errors in the TPS, plan transfer to the delivery system and treatment delivery. This work reports on algoritm development to predict the DAVID signal.

The lateral response from primary and scattered radiation was characterised. Convolution of this with the individual segment leaf separations in step-and-shoot plans, plus leaf leakage and penumbral drop-off corrrections, provide expected signals for each wire. This simple predictive approach was applied to a range of clinical head-and-neck IMRT plans. Averaged signals for each plan from five measurements were compared to prediction. Percentage differences between maximum predicted and measured signals were evaluated for the whole treatment; defining failed deliveries with differences >5% . Providing this test was passed, a set tolerance of 5% of maximum was applied to the individual wire signals, for each field.

All treatments investigated passed. The algorithm could detect artificially-induced 5% changes in MU delivery. This fast and relatively simple algorithm accurately predicts the DAVID responses and enables in-vivo verification of IMRT dose-delivery without requiring separate pre-treatment linac time .

Paper Number: 0363

DOES TECHNICAL DIFFICULTY OF ENDOSCOPIC PROCEDURES AFFECT PATIENT RADIATION DOSE?

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INTRODUCTION

The aim of this study was to investigate whether a correlation between technical difficulty of endoscopic procedure and fluoroscopy time and/or patient radiation dose exists.

PATIENTS-METHODS

650 patients were retrospectively analyzed. A validated technical difficulty grading scale was applied: 1) Simple stone cases 1-2 stones <1 cm , 2) Complex stone cases with >2 stones and/or >10mm and 3) Pancreatic endotherapy of Bill II and/or intrahepatic stones 4) non endoscopic retrograde cholangiopancreatography (ERCP) endoscopic procedures and 5) failed ERCPs. All procedures were performed by one senior endoscopist with more than 10 years experience. Fluoroscopy time (T), number of films (F) and patient radiation dose in terms of Kerma area product (KAP) were recorded.

RESULTS

Median values of all radiological data are presented in the following table.

Category of procedure

N	pat	Age	T	F	KAP
1	407	74	2,8	2	8,71
2	157	73	4,7	2	14,92
3	20	73,5	3,1	2	11,54
4	52	77,5	3,4	2	10,72
5	14	73	1,7	2	3,64

The most frequent procedures were number 1 and 2. It appears that number 2 imparts more radiation dose compared to number 1 due to increased fluoroscopy time. Regarding category 3, total number of cases was extremely low compared to 1 and 2 categories, so safe conclusions cannot be drawn.

CONCLUSION

Increasing technical difficulty of the endoscopic procedure clearly affects T and KAP.

Paper Number: 0124

DOSE AND IMAGE QUALITY OPTIMISATION FOR PLANAR AND TOMOSYNTHESIS IMAGING IN DIGITAL MAMMOGRAPHY

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INTRODUCTION

Exposure parameters and target filter combinations in digital mammography are selected to maximise contrast between adipose and glandular tissue with as low a patient dose as possible. Image quality is not linearly dependent upon dose and acceptance parameter settings may not be optimised to give the lowest doses with clinically adequate image quality. The CDMAM phantom allows quantitative image quality evaluation and can test resolution and contrast response. Possible dose reduction without loss of image quality should be investigated.

AIM

Optimisation of contrast-detail and dose characteristics of a digital mammography system varying exposure parameters and target filter combinations for planar imaging and tomosynthesis.

METHODS

A clinical full field digital mammography system was used to acquire planar and tomographic images of the phantom for various exposure parameters and geometries and the average glandular doses were determined. Three experienced viewers quantitatively evaluated the images.

RESULTS

For the W/Ag combinations, at 28 and 36kVp, the image quality became significantly different from that for the standard parameters at 43% and 27% of the dose respectively ($p<0.05$). Generally the image quality fell when exposure parameters for 28 and 36kVp fell to delivering <50% of the dose to the patient. The image quality did not vary significantly with depth in the phantom.

CONCLUSION

This phantom study shows image quality will not be compromised with a 40% reduction in patient dose. Effects on sensitivity and specificity of reporting will have to be evaluated in a clinical trial. The priority remains diagnostic content over lowered radiation dose.

Paper Number: 0369

DOSE ESTIMATION FROM X-RAY EXPOSURES DURING DIAGNOSTIC MEDICAL PROCEDURES FOR SOME ADULT PATIENTS IN LIBYA

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An attempt was made to initiate a study to be carried out for the first time in Libya. This work involves the estimation of dose during radiographic examinations for adult patients in one of Benghazi-Libya's hospital (Alhawari General Hospital). Effective dose (ED) in mSv was calculated for 101 adult patients with the following examinations, abdomen AP, chest PA, cervical spine AP, pelvis AP and lumbar spine AP. The most frequent examination was chest PA (76%). The x-ray equipment parameters for each patient exposure such as kilovolt peak, kVp, milliampere second, mAs, focus film distance, FFD, filtration were also recorded. The x-ray equipment was calibrated using an ionisation chamber in order to convert x-ray exposure into dose. Dosecal program which employs a well known formula was used in these calculations. The technique used in calculating ED was based on dose area product, DAP, in cGy cm2 which is then converted into ED values. The mean ED in the present study for adult patients undergoing chest PA, abdomen AP, pelvis AP, cervical spine AP and lumbar spine AP were found to be 0.025, 0.186, 0.540, 0.040 and 0.501 mSv respectively . These dose levels compare well with international surveys from many countries and international organizations

Paper Number: 0291

DOSE OPTIMISATION IN CARDIAC X-RAY IMAGING

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BACKGROUND

Interventional X-ray systems used for cardiac catheterisation procedures are operated by pre-programmed automatic dose rate control. Radiographic factors are automatically selected based on imaging geometry and estimated patient thickness - which depends on image projection as well as patient size.

PURPOSE

The aim of this research was to determine optimal X-ray beam energy for cardiac image acquisition in a system-independent manner, for a range of paediatric and adult patient sizes.

METHODS

Patients and iodine based contrast medium were simulated using polymethyl methacrylate (PMMA) and tin respectively. X-ray tube voltage (kVp) and Cu X-ray beam filtration were independently varied and images were captured on a flat panel detector based cardiac X-ray imaging system. Tin detail contrast was calculated and flat field image noise was measured to determine the contrast to noise ratio (CNR). Entrance surface and effective dose measurements were obtained to calculate CNR2 / dose, which determined dose efficiency.

RESULTS

Lower kVp was favoured, more so for thinner PMMA; as Cu increased, lower kVp was favoured. For the smallest phantom (8.5 cm), CNR2 / dose was highest at 50 kVp with 0.4 mm Cu considering both dose measurements. For the largest phantom (30 cm), using 80 kVp with 0.25 mm Cu and 85 kVp with no filtration provided the highest CNR2 / dose for entrance surface and effective dose respectively.

CONCLUSIONS

Optimal beam energy can be used, with X-ray dose adjusted for clinically acceptable image quality and X-ray tube loading limits, for a given task and patient size.

Paper Number: 0164

DOSE REDUCTION EFFECT IN A BIG BORE CT USING A COMMERCIAL ITERATIVE RECONSTRUCTION TECHNIQUE: A PHANTOM STUDY

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We investigated the HU difference due to the commercial iterative reconstruction technique in order to reduce the imaging dose. The phantom with various density materials from 0.2 g/cc to 1.53 g/cc was scanned by the Philips Big Bore CT, using two energies (90 and 120 kV) and four currents (50, 100, 200 and 400 mAs). After CT scanning, the raw images were reconstructed with and without iDose (Philips) with level 5. The maximum, minimum, mean and standard deviation (SD) of HU were evaluated. The HU showed the higher value as the x-ray energy is lower and the material density is higher. The SD of HU was decreased with the increase of energy (kV) and dose (mAs). As the density is higher, the use of iDose increased the mean HU that the maximum change of mean HU was 109 HU in 1.53 g/cc bone core material at 90 kV. At the same energy, the HU with mAs showed a difference less than 27 HU. The amount of HU change due to the iDose was decreased as the density is closer to the water (1 g/cc). Therefore, this technique in big bore CT can be used for the soft tissue because the imaging dose reduction does not significantly change the HU and electron density. However, it should be used with a caution for the dose calculation in the treatment planning because the HU change with iDose is increased as the density is higher.

Paper Number: 0240

DOSE VERIFICATION OF 180 TOMOTHERAPY PLANS USING ARCCHECK DEVICE

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PURPOSE

The aim of this work is to report the results of dosimetric verification of TomoTherapy plans performed with ArcCHECK device. ArcCHECK repeatability and absolute dose calibration accuracy were also investigated.

MATERIALS AND METHODS

One hundred and eighty patients with lesions in various anatomical regions and dose per fraction ranging from 0.9 Gy to 10 Gy were included in the study. Dose verifications were performed using ArcCHECK: a cylindrical phantom with 1386 diodes arranged on the external surface. A PMMA plug inserted into the phantom hosts an Exradin A1SL ionization chamber. For each patient a quality assurance plan was prepared using the DQA software (provided by TomoTherapy). A treatment procedure was generated and the planned DQA plan was delivered to the phantom. Evaluation was performed (with dose difference = 3% and distance to agreement = 3 mm) scoring the gamma passing rate. Percentage point dose agreement was also performed. Prior to start with patient plan verification ArcCHECK performances were investigated. Device repeatability was tested delivering several times the same uniform plan while the dose calibration accuracy was tested delivering the same plan to different diodes.

RESULTS

ArcCHECK repeatability and dose calibration accuracy resulted about 2% and 1,5% respectively. Mean absolute and relative gamma passing rates and point dose agreement resulted 90,6%, 97,47% and -0.16% respectively.

CONCLUSIONS

ArcCHECK device was found satisfactory in terms of reproducibility and dose calibration accuracy. Good agreement between measured and calculated dose demonstrate the dosimetric accuracy of TomoTherapy delivered plan.

Paper Number: 0334

DOSIMETRIC EFFECT AND COMPENSATION OF COUCH RAILS IN SBRT LUNG TREATMENTS

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PURPOSE

To study the dosimetric effect of couch rail attenuation on SBRT lung treatments and its effective compensation in treatment planning.

METHODS

Dose perturbations caused by Varian EXACT couch rails left in the beam aperture in SBRT lung treatments were analyzed on Eclipse planning system by "inserting" couches to the planning images. First, individual beams that went through the rails were identified and dose attenuations for those fields were calculated. Second, SBRT plans with and without couch rails in the beam apertures were compared. Third, dose variations due to daily couch position differences were analyzed using couch parameters recorded after each daily IGRT setup. Composite plans of all delivered fractions were compared to the idealized plan without couch position variation.

RESULTS

For a single 6 MV beam that went through the couch rail the beam was attenuated by ~6.4%. For a nine-field SBRT plan the isocenter dose was reduced by ~1.5%. However, PTV coverage by the prescription isodose line (85%) changed from 87.2% to 83.4%. The composite plan with couch position variations does not show clinically significant difference from the idealized plan.

CONCLUSION

Moving couch rails out of the beam aperture were routinely ignored during daily treatments. For SBRT cases with only a few fractions and relatively large number of fields "inserting" the couch in the planning images improves the accuracy of the dosimetry. Small daily couch position variations for lung SBRT treatments do not cause clinically significant dose differences.

Paper Number: 0222

DOSIMETRIC IMPACT OF INTENSITY MODULATED BRACHYTHERAPY WITH IMRT FOR CERVICAL CANCER: THE AIIMS EXPERIENCE

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PURPOSE

To evaluate the dosimetric impact of intensity modulated brachytherapy (IMBT) with classical brachytherapy optimization and also with IMRT in patients of cervical carcinoma.

MATERIALS AND METHODS

Ten patient of cervical cancer who had already undergone interstitial HDR brachytherapy with MUPIT template were selected. The image guided implantation procedure was done under transrectal ultrasound (TRUS). The PLATO system for Microselectron-HDR interstitial template brachytherapy. The plans were made for dose point optimization (DPO), geometric optimization (GO), Inverse planning simulated annealing (IPSA). The Eclipse system was used for IMRT planning to 10Gy as prescription dose. All plans were evaluated using dosimetric indices such as V90, V95, V100, V150 and V200, coverage index (CI), conformity index (COIN), dose non-uniformity ratio (DNR), homogeneity index (HI) and external volume index (EI) for target. For OARs, D1cc, D2cc, D5cc V50 and V75 were evaluated for both bladder and rectum.

RESULTS

The difference was calculated with respect to conventional brachy plan optimization. The maximum difference in V95 was 16.8%, 18.1%, and 33.6% in DPO, GO, and IPSA respectively. The difference in COIN was 58.1% for IPSA with conventional plan. The differences in DNR, EI, HI between classical optimizations and inverse optimizations were significant ($p<0.0001$). The differences for IPSA in D5cc was 30.7% and 33.9% and in V75 the difference of 47.8% and 51.8% for both rectum and bladder respectively ($p<0.001$).

CONCLUSION

The IMBT resulted in improved dose conformity and homogeneity and reduced dose to OAR compared optimization techniques.

Paper Number: 0178

EFFECT OF COMBINATION OF ACUTE EXPOSURE TO 50 HZ ELECTROMAGNETIC FIELDS AND CALCIUM CHANNEL BLOCKERS ON MICE'S MOTOR COORDINATION

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Behavioral studies on animals provide a useful indicator of the possible cognitive effects on human. Exposure to extremely low-frequency electromagnetic fields (ELF-EMFs) fields may affect neurobehavioral functions in animals. Several studies have shown that ELF-EMFs affect cholinergic neurotransmitter systems in the brain, and this is supported by the results of studies investigating the effects on analgesia and on the acquisition and performance of spatial memory tasks. However, few studies have investigated the effect of ELF-EMFs on motor coordination. In this study, we investigate the possible effect of ELF-EMFs on the motor performance in adult mice, also the role of calcium channel blockers (CCB) in manipulating EMFs hazards is investigated. Mice were exposed to 1mT, 50 Hz EMFs, for 5 days (2 hour/day) in a Helmholtz coil system immediately before each training session. A second group was pretreated with calcium channel blockers (CCB) (amlodipine 3mg/kg/day) for four weeks and similarly exposed to EMFs. A third group was non-exposed control animals. Rota-rod experiments were performed on the three groups. The effect of rotation speed (45,50,55,60 rpm) was tested for a 5-day course. Results from the Rota-rod experiments demonstrated a pronounced enhancement in the learning abilities of the two exposed groups. It is assumed that motor learning is controlled by complex interactions between the supplementary motor area, prefrontal parietal cortex, basal ganglia and cerebellum. Therefore, the alteration in the learning abilities could be attributed to the ELF-EMFs causing a change in the underlying structure and/or function of these brain regions.

Paper Number: 0290

EFFECT OF DIFFERENT PHANTOM MATERIALS ON THE CENTRAL AXIS DOSE OF THE OPHTHALMIC PLAQUES

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In order to calibrate the ophthalmic plaques used in brachytherapy of the ocular tumors, water and Plexiglas phantoms are employed. Any discrepancy from the real dose using these materials was investigated. Ophthalmic plaque and the surrounding tissue were simulated using Monte Carlo method.

Simulation of the eyeball and CCB plaque of Ru-106 was done using MCNP-4C code and the dose rate was calculated with using *F8 tally in spheres with the radius of 0.2 mm on the central axis in distances of 0.3 to 7 mm from the plaque surface. The eyeball was simulated with three different materials including real tissue, Plexiglas, and water.

The results of the simulation demonstrated that the absorbed dose rate on the central axis of plaque in water phantom differed slightly with the eyeball tissue. However, this difference increased significantly using the Plexiglas phantom. The average difference was 4% for water and 11% for Plexiglas compared to the real eyeball tissue. Another important result was the change in the trend of the absorbed dose for the three materials at the distance of 2.5 mm from the plaque surface. At this point, the dose rate in the three materials showed the least difference. At the points nearer to the plaque surface, the Plexiglas phantom received higher dose rate than the others; nevertheless at farther distances the trend reversed. Therefore, the use of water phantom is recommended for calibration of ophthalmic plaques. In addition, correction factors should be applied to the treatment time calculated using Plexiglas phantoms.

Paper Number: 0018

EFFECTIVENESS OF 18F DG PET/CT VERSUS I131 WHOLE-BODY SCAN FOR THE DETECTION OF MALIGNANT THYROID RESIDUAL TISSUES.

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CASE REPORT:

Clinical History and Result: A 19 years-old female with papillary carcinoma was treated with near total thyroidectomy, followed by I131 ablation dose of 3700 MBq. For eighteen months her case was stable; Thyroglobulin (Tg) serum level <10ng/ml and I131 WBS was negative. Early in the third year and following a routine check-up, Tg has risen to 21ng/ml while I131WBS was negative. In view of suspicion of metastases, the patient was referred to 18FDG PET/CT for restaging. A small focal hyper metabolic lesion in the left lower neck (10x10mm) was detected with a high SUVmax of 5.6. Discussion: The hot area appeared on the PET/CT is most probably I131 radio-resistant thyroid tissue which seemed unable to metabolize iodine and results in negative I131WBS. The PET positive response with a relatively high SUVmax value gives indication that these cells are most likely malignant. Three approaches may be considered: (1) keep patient under observation and suppressive thyroxin, (2) treat with a high dose of 131I, and (3) use alternative imaging technique. We recommended I131 ablation dose and follow up in six months. If high Tg value persists, different treatment strategy shall be adopted. Chemotherapy and/or external radiotherapy are available options. We propose external infra-red laser thermal ablation therapy for future research, whereby Deoxy Glucose (DG) is labeled with an IR absorbing medium.

CONCLUSION:

PET/CT is most useful in the detection and management of malignant thyroid residual tissues in patients with Tg levels >10ng/ml accompanied by negative I131 WBS.

Paper Number: 0177

EFFECTIVENESS OF STERILE RADIATION PROTECTION DRAPE IN INTERVENTIONAL FLUOROSCOPY PROCEDURE

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Interventional radiologists have the highest occupational radiation doses among the medical workers. Their main source of exposure is the radiation scattered from the patient. The exposure can be minimized by using personal radiation protection or lead shields attached to the ceiling or to the table-side. However means for radiation protection for the staff may be limited during intervention. Then the amount of radiation scattered from the patient may be lowered by placing a sterile lead drape on the patient. These scattered radiation shields add to the cost of procedure and their use require care and addiational effort.

The aim of this work was to assess the effectiveness of a sterile scattered radiation shield in the protection of staff during fluoroscopy in interventional procedures.

RADPAD® scattered radiation shield 5110A-O was placed on the side of the torso of an antropomorphic phantom. Siemens Artis was used in posteri-anterior direction for fluoroscopy. The radiation field was centered on the lumbar vertabra and RaySafe Xi dosemeter was used to measure the scattered radiation dose.

The dose rate of the scattered radiation was measured at 50 cm, 100 cm at 150 cm distance at 90 and 45 degree angle. Also the effect of the field size was measured. The measurements were performed with and without the scattered radiation shield and the dose rates were compared.

The use of scattered radiation dose shield radured the dose rates at measurement points by 61-76%. Scattered radiation shield may be used to effectively to shield the staff during interventional procedures.

Paper number **0120**

EFFECTS OF IMAGING PARAMETERS ON VOLUMETRIC BREAST DENSITY MEASUREMENT

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Volumetric breast density (VBD) measurement systems are increasingly being used in clinical applications, particularly in the estimation of breast cancer risk and radiation dose monitoring, but they are known to be sensitive to errors in the imaging physics parameters. We investigated the robustness of one such system, Volpara, to errors in the imaging parameters. We processed digital mammograms from GE Essential, Siemens Novation and Hologic Selenia systems using Volpara 1.4.3 to obtain VBD. For simulating errors in the imaging parameters, we varied the values of the DICOM tags for compressed breast thickness, tube voltage (kVp), tube current-exposure time product (mAs), target material, filter material and filter thickness of the images. We also adjusted the image itself for simulating changes in detector gain, detector offset and image noise. Varying the mAs had no effect on VBD as calculated by Volpara, and negligible or very little effects were observed from varying detector gain and filter thickness, and adding image noise (effect dependent on type of noise added). Significant effects were introduced by varying kVp (+5 kVp yielded a 21.6% error), switching target material (molybdenum to tungsten yielded a 10.6% error), switching filter material (rhodium to tungsten yielded a 49.9% error), adjusting detector offset (-100 pixels yielded a 24.9% error) and by substantially adjusting compressed breast thickness (effect dependent on specific image and starting value). Our results highlight the increasing importance of implementing routine quality assurance tests as volumetric breast density measurement systems, for instance, Volpara are being used clinically.

Paper number 0094

EMPLOYEE RADIATION RISK IN CARDIAC CATHERIZATION LABORATORY - MONTE CARLO CALCULATIONS AND TLD MEASUREMENTS

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Cardiac catherization and angiography interventional procedures lead to higher exposures of patients and personnel than do other procedures in diagnostic radiology. In an effort to evaluate X-ray doses received by the medical staff in catherization unit of a cardiology department, Monte Carlo calculation using MCNPX code was performed. Exposures were also measured in air using thermoluminescent dosimeters (TLD) within a three-dimensional grid of about 100 regularly spaced measurement points placed inside the operating room. The aim of these MC simulation and measurements was to obtain a 3-D dose distribution at some distance around the X-ray unit, generated during standard interventional cardiology procedures. This part of the project was intended to highlight areas of highest X-ray exposure during catherization, of relevance to the positioning of the medical personnel around the operating table during the procedure. In all measurements standard TL badges for environmental monitoring, calibrated in terms of air kerma in water, each containing two high sensitive MCP-N (LiF:Mg, Cu, P) detectors, were used. Results of environmental measurements were compared with dose distributions calculated using the MCNPX (Monte Carlo N-Particle X Transport) Code. Comparison of MC calculations and TL measurements shows some differences (5-10% in high dose-rate region up to 20% in low dose-rate areas). MC calculation even for simplified models can be used to determine areas important for radiation protection.

CONCLUSION

Placement of personal dosimeter should be analysed according to character of work. In our opinion, placement of dosimeter on a belt for nurses, allow for better radiation risk estimation.

Paper number **0012**

ENTRANCE RADIATION DOSE DETERMINATION FOR SELECTED CANCER PATIENTS AT THE LAGOS UNIVERSITY TEACHING HOSPITAL, NIGERIA.

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An in-vivo dosimetry was conducted to assess the precision of radiation dose delivery to Radiotherapy cancer patients at the Lagos University Teaching Hospital (LUTH), Nigeria. Entrance dose for 30 patients of diverse cancer presentations were determined using in-vivo Thermoluminescence dosimetry (TLD) technique. The TLD system which had earlier been calibrated was from the Rados technology, Turku, Finland. The ELEKTA clinical Linear Accelerator (LINAC) available at the LINAC Center of the Radiotherapy Department served as the source of the 6 MeV photon beam. A cylindrical ionization chamber (Type/ser: TM31010-1338) and electrometer (Type/Ser: T100001-11478) were used for pre-calibration of the LINAC. The patients were treated under the normal conditions with TLD detectors placed at suitable points in the beam on the patient's skin, under a dose build-up material. The results obtained show that about 90 % of the patients studied received doses that were within the recommended precision ± 5 % limits compared with prescribed dose. The slightly high deviations between the prescribed and delivered doses in 10 % of studied cases are ascribed to obliquity factors. The results demonstrate reasonably good practice within the prevalent technical limitations.

Paper Number: 0243

ESTABLISHING THE OPTIMUM PARAMETERS FOR CLINICAL TESTING OF THE VESTIBULO-OCULAR REFLEX

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The vestibulo-ocular reflex serves to maintain clarity of vision during head movements through a compensatory rotational movement of the eyes. Patients suffering from problems with their vestibulo-ocular reflex often experience visual blurring. This can lead to nausea, limit social interaction and increase isolation. Economic effects to the health service as a consequence of these problems are profound. Current protocol for the diagnosis and rehabilitation of vestibular defects is protracted, complex and has a number of well documented associated problems.

To instigate the vestibulo-ocular reflex during clinical testing, patients are required to axially rotate their head in a cyclic manner. Perhaps the most significant problem with current testing procedures is the inability to ensure that the vestibulo-ocular reflex is isolated from other compensatory eye movements that occur at lower rotational speeds.

In order to establish the parameters required to achieve a rotational head speed of sufficient angular velocity to isolate the vestibulo-ocular reflex, a clinical testing procedure has been developed. The clinical trial will involve both normal subjects and those diagnosed with vestibular defects. A number of variables that are expected to influence rotational head speed will be investigated. These include the frequency of head rotation, the plane in which the head revolves and whether the movement is active or passive. All measurements will be acquired from reflective markers at a sampling frequency of 120 Hz using an OptiTrack V120: Duo.

Paper Number: 0051

ESTABLISHMENT OF DIAGNOSTIC REFERENCE LEVELS IN UKRAINE

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The X-ray diagnostic is the dominating method because more 80% of diagnoses are established due to it. Unfortunately the contribution of X-ray diagnostic doses into the collective doses of population is very high and needed in optimization. One of the most efficient tool in optimization of patient's doses in Diagnostic Radiology is the establishment of national diagnostic reference levels (DRLs).

The aim of this study was to study the doses of ‘ patient for most typical examinations in radiology departments in Ukraine and to estimate the national DRLs.

The survey of adult patient doses in X-raywas carried out during 2009- 2011. The most common types of X ray diagnostic examinations were determined from the frequency analysis of the X ray examinations in all regions of Ukraine.

The distributions of entrance surface doses (ESDs) for main radiography examinations were studied. For 10 types of X ray examinations the DRLs were accepted as the third quartile of ESD's distributions. For following types of radiography exams they were: Chest (PA) - 0,9 mGy; cervical spine - 2,0 mGy; thorax - 11,0 and 18,0 mGy, lumbar - 15,0 and 40,0 mGy (AP and LAT); pelvis - 15,0 mGy (AP).

For the majority of radiography examinations the value of DRLs were exceeded by 2.0-2.5 times the Guidance Levels from IAEA Basic Standards (BSS-115).

Results of research work have shown that optimization radiation protection of patients in diagnostic radiology is possible due to the patient dose monitoring (ESDs) and comparison these doses with national DRLs.

Paper Number: 0151

ESTIMATION OF ABSORBED DOSE IN CLINICAL RADIOTHERAPY LINEAR ACCELERATOR BEAMS – EFFECT OF ION CHAMBER CALIBRATION AND LONG TERM STABILITY

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The accuracy in measured dose in water at reference point in phantom is a primary parameter for planning the treatment monitor units (MU), both in conventional and intensity modulated/ image guided treatments. Traceability of dose accuracy therefore still depend mainly on the calibration factor of the ion chamber/dosimeter provided by the accredited secondary standard dosimetry laboratories (SSDL), under IAEA accredited laboratories.

The data related to Nd,water calibrations, TLD postal dose validation, intercomparison of different dosimeter/electrometers, validity of Nd,water calibrations obtained from different calibration laboratories, were analyzed to find out the extent of accuracy achievable.

Nd,w factors in Gray /Coulomb calibrated at IBA, GmBH, Germany showed a mean variation of about 0.2% increase per year in 3 Farmer chambers, in 3 subsequent calibrations. Another ion-chamber calibrated in different accredited laboratory (PTW, Germany) showed consistent Nd,w for 9 years period. The Strontium-90 beta check source response indicated long term stability of the ion-chambers within 1% for 3 chambers. IAEA postal TLD inter-comparison for 3 photon beams 6MV(2), 15 MV(1), were well within our reported doses, with mean deviation of 0.03% (SD 0.87%) (n=9). .

All the chamber/electrometer calibrated from a single SSDL realize absorbed doses in water within 0.13% standard deviations. However about 1-2% differences in absorbed dose estimates observed when dosimeters calibrated from different calibration laboratories are compared in solid phantoms. Our data therefore infers that the dosimetry level maintained for clinical use of linear accelerator photon beams are within recommended levels of accuracy, and uncertainties are within reported values.

Paper Number: **0014**

ESTIMATION OF A/B PARAMETER OF LINEAR QUADRATIC MODEL FOR TUMOR AND NORMAL TISSUE DURING RADIOTHERAPY OF CANCER CERVIX AND CANCER HEAD & NECK.

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The primary objective of radiotherapy of cancer patient is to deliver a lethal dose to cancer cells without inducing irreparable or unacceptable damage to the surrounding normal tissue and organs at risk. To achieve this objective various dose fractionation schedules and protocols are practiced in radiotherapy to increase the radiation effect on malignant cells with sparing the damage to normal cells as much as possible. In order to compare the biological effectiveness of these various fractionation regimes quantitatively many mathematic concepts like NSD, CRE & TDF were proposed and used despite of many draw backs.

The LQ model is proved to be superior to earlier empirical models due to use of tissue specific parameters.

In present study we have used four different fractionation schedules to treat 450 cancer patients of cervix uterus and Head & neck region as follows

1.	2 Gy/F,	5F/wk,	30 – 35 F	total dose	60 - 70 Gy.
2.	1.2 Gy/F,	10F/wk, (2F/d) ,	58 - 66 F	total dose	69.6 – 79.2 Gy
3.	1.4 Gy/F,	10F/wk, (2F/d),	48 - 54 F	total dose	67.2 - 75.6 Gy
4.	1.6 Gy/F,	10F/wk, (2F/d) ,	40 - 44 F	total dose	64.0 - 70.4 Gy

The tumor control rates and normal tissue complications of all the four fractionation schedule are assessed and compared based on LQ model. Further we have estimated the α/β parameter for tumor and normal tissue early reactions. The detailed results are presented in this communication.

Paper Number: 0134

EVALUATION METHOD OF THE PLANNING DOSE DISTRIBUTION ON THE VIRTUAL BRONCHOSCOP

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In the clinical evaluation of lung cancer for radiotherapy, fiber-optic bronchoscopy is a crucial tool in the diagnosis of the tumor region before the treatment and in the evaluation of dose responses on tumor and normal tissues after the treatment. Although the bronchoscopic image is useful to understand the tumor involvement, the conventional display for planning dose distribution is multi-planner reconstruction system. Therefore it is so complex to correlate the dose distribution with the bronchoscopic image. To estimate effects of irradiation on lung tumor around bronchi, we have developed the visualizing application of planning dose distribution on virtual bronchoscopic images. The virtual bronchoscopy is reconstructed from volumetric CT data set for treatment planning, and the planning dose distribution is mapped on the virtual endobronchial surface using volume rendering technique. Radiation oncologist could evaluate the planning dose distribution from the endoscopic perspective. Our unique dose distribution display system assists the comparison between the planned dose distribution and the dose response observed by endoscopy.

Clinical evaluation by this technique was performed to 14 case of lung cancer treated with carbon-ion radiotherapy until March 2013. The validity of the planned dose distribution has been checked from tissue responses such as tumor disappearance and bronchial obstruction after irradiation. In this report, we introduce some clinical cases.

Paper Number: 0364

EVALUATION OF 32-P APPLICATOR FOR POSTOPERATIVE IRRADIATION AFTER PTERYGIUM EXCISION

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A Pterygium is an elevated, superficial, external ocular mass that usually forms over the perilimbal conjunctiva and extends onto the corneal surface.

In Postoperative Irradiation after Pterygium Excision, 90-Sr applicator is utilized as a pure beta-emitter with maximum energy of 2.17 MeV. Also, 32-P which is considered to be a pure beta-emitter (Emax=1.7 MeV) could be an alternative for this specified application. In this paper, we intend to evaluate the possibility of 90-Sr replacement with 32-P. So, 32-P and 90-Sr applicators, eyeball contained of water, plexi-glass and real tissue has been simulated separately in MCNP4C environment. For each source, using *F8 tally, axial absorbed dose has been calculated for inner volume of spheres with 0.2 mm radius. Averaged statistical error for the simulations is approximately 4 percent.

Eyeball absorbed dose (D) and percentage depth dose (PDD) have been calculated and plotted as function of distance from sphere surface. Results have shown that the dose gradient for 32-P is much greater than 90-Sr for the mentioned materials. For example curves have shown that %50 PDD for 90-Sr and 32-P is placed at 1.5 mm and 2 mm distance respectively.

In Postoperative Irradiation after Pterygium Excision, keeping safe “organs at risk” especially lens, are of primary importance. So considering the greater dose gradient of 32-P relative to 90-Sr, in proposed applicator, healthy tissues absorbed dose will be relieved. In conclusion, 32-P would be a well-fitted alternative for Postoperative Irradiation after Pterygium Excision.

Paper Number: 0247

EVALUATION OF DOSE DISTRIBUTION CHANGES PRIOR TO MIGRATION TO MONTE CARLO ALGORITHM BASED ELECTRON BREAST BOOST RADIOTHERAPY PLANNING

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AIM

A parallel plan study was carried out to evaluate the effect of implementing computerized planning of electron radiotherapy treatment. This formed the final stage of a project implement electron beam data for the treatment planning system (TPS). The dose delivered calculated by Monte Carlo (MC) algorithm in Oncentra MasterPlan (OMP) TPS was compared to the intended dose from the manual calculation planning approach.

METHOD

The study compared plans for patients already receiving electron therapy as this would indicate true clinical intent for coverage and decision-making. We decided to consider breast patients receiving an electron boost field as these patients already undergo a planning CT scan for the photon portion of their treatment, which would be require for MC calculation. No additional medical exposure to ionizing radiation would therefore be necessary.

Electron breast boost cases were retrospectively planned, using parameters from existing manual calculation plans, using the VMC++ algorithm in OMP. A boost planning target volume was drawn by the clinicians in 18 cases.

RESULTS

An average point dose deviation for all 32 cases of -5.8% was observed), with most cases falling within 0 to -10%.

Inspection 18 cases with delineated PTVs found 10 required a major change to meet planning outcome criteria, while 2 were found to be unsuitable for planning with electrons due to excessive target depth.

CONCLUSION

Changes in monitor units required to deliver the same dose were within reported ranges. Delineation of PTV showed a need to increase energies used to achieve proper coverage.

Paper Number: 0272

EVALUATION OF EYE LENS DOSE DURING NEURO-INTERVENTIONAL PROCEDURE

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PURPOSE OF STUDY

This study considered the difference between the absorbed dose to the patient's eye lens and absorbed dose at position near the outer canthus area during the neuro-interventional procedures.

Materials and method

MOSkin™ detector calibrated under diagnostic energy range was utilized in this study. Characterization of this detector was also considered energy dependency, sensitivity, and angular dependency of MOSkin detectors under low energy x-ray.

MOSkin detectors were placed at 1 cm lateral from the patient's outer canthus and on patient's eyelid. The relationship between the dose-area-product (DAP) delivered to the patient and the lens dose was also studied.

RESULTS

The measured absorbed dose by patient's eye and outer canthus area revealed that eye lens receives significantly lower dose, 10.8 ± 2.9 cGy, in compare to outer canthus part, 15.5 ± 4.7 cGy, and placing the detector at outer canthus area could lead to an overestimation of the lens dose as much as 43%. The main reason for this difference is, the lateral tube generally is placed beside of the patient's head and outer canthus area is closer to the lateral tube, and outer canthus part mostly receives primary x-ray radiation from lateral tube.

CONCLUSION

The information of absorbed dose during the fluoroscopic procedures can help radiologist to monitor the patient's eye lens dose to prevent and reduce the potential of the deterministic risks, but for studying the dose absorption during treatment using a real time dosimeters with high accuracy is so essential.

Paper Number: 0219

EVALUATION OF INHERENT DOSE-UNCERTAINTY FOR VMAT USING A DOSE-UNCERTAINTY MODEL

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PURPOSE

To investigate the dose-uncertainty, which can occur during treatment planning and dose delivery in volumetric modulated arc therapy (VMAT), by generalizing the dose-uncertainty model.

METHODS

QA plans for prostate cancer patients treated with VMAT were created for a water phantom (40x40x20 cm3) using Pinnacle3 radiation treatment planning (RTP) system (Philips Radiation Oncology Systems, WI, USA). The plans were exported as DICOM RT dose files from RTP, and the files were processed using an in-house program to obtain the dose-uncertainty map. Inherent uncertainty of dose calculation (IU) was evaluated in this study. The IU considered was originated from the error of dose in a high-dose gradient region caused by the finite size of the calculation grid and the finite size of the detector system during RTP commissioning. The IU was calculated for each control point and was summed up to obtain total IU for each VMAT plan.

RESULTS

Dose-uncertainty distribution on the isocenter plane in the axial slice was investigated. The maximum IU, which was around 10 % of the prescribed dose, appeared the boundary between the target and the OARs (bladder and rectum).

CONCLUSIONS

In this study, the inherent dose-uncertainty map was evaluated using the dose-uncertainty model generalized for VMAT, and applied to VMAT plans for prostate cancer patients. IU of VMAT spread out around the target if compared with that of IMRT plan. The maximum dose-uncertainty was found in the boundary between the target and OARs and was about 10 % of prescribed dose.

Paper Number: 0199

EVALUATION OF MEAN GLANDULAR DOSE FOR DIGITAL BREAST TOMOSYNTHESIS (DBT) USING A SEMI-ANALYTICAL MODEL

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Digital breast tomosynthesis (DBT) is a 3-D imaging technique that has higher sensitivity and specificity, compared to mammography, for early diagnostic of breast cancer, with a similar radiation dose. The risks associated with the DBT examination is evaluated with respect to the mean glandular dose, determined from air kerma measurements and specific normalized glandular dose factors. In this work, we describe semi-analytical models, which were developed to study the normalized average glandular dose (Dgn) in DBT, by determining the deposited energy in single and double interactions. The semi-analytical model was used to study the dependence of the normalized glandular dose for different projection angle, different breast thicknesses and glandularities. The anode/filter combinations evaluated were: Mo/Mo, Mo/Rh and Rh/Rh, and a W anode combined with K-edge filters (Zr, Mo, Nb, Ru, Rh, Pd, Ag, Cd, In and Sn), for tube potential between 23 and 35 kV. Results demonstrate that the normalized glandular dose decreases up to 25%, as the projection angle increases, being this decrease most pronounced for thicker and denser breasts. Besides, it was observed variations up to 50% and 70% on the normalized average breast dose with the x-ray spectra and breast characteristics (composition and thickness), respectively. Finally, it was verified that the semianalytical models developed in this work provided results of normalized glandular dose in DBT in a fast and simple way, with a good agreement with those or by MC simulation (discrepancies lower than 10%).

Paper Number: **0015**

EVALUATION OF MEAN GLANDULAR DOSE FROM DIGITAL MAMMOGRAPHY EXAMS AT HAMAD MEDICAL CORPORATION HMC AND COMPARED WITH INTERNATIONAL GUIDANCE LEVELS

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The primary objective of this study is to measure the mean glandular dose (MGD) from craniocaudal (CC) and mediolateral oblique (MLO) views from mammography patients in Hamad Medical Corporation (HMC) and to compare them with the international guidance levels. All patients` data was taken from two Selenia digital mammography units for 18 months period. Quality control was implemented for two the mammography machines and the correction actions have been done for the image quality evaluation with rejected film analysis.

The total number of collected patient data was 4085 mammography exams which considered around 93% of the overall mammography procedures done in Qatar during that period.

Based on the IAEA selection criteria of breast thickness between 2-7 cm and kV machine value from 26 to 33 kV, only 3280 mammography procedures satisfies the above criteria and are analysed accordingly (National Centre for Cancer Care & Research (NCCCR) 949 and Hamad General Hospital- HGH- 2331 exposures).

Referring to the limiting dose values in the European guidelines, the results from the two mammography units showed that 94.5% and 99.7% of the mean glandular doses are acceptable from NCCCR and HGH respectively.

Paper Number: 0181

EVALUATION OF STAFF DOSE REDUCTION FOR DIGITAL SUBTRACTION ANGIOGRAPHY WITH A NEW IMAGE NOISE REDUCTION ALGORITHM FOR PERIPHERAL ANGIOGRAPHY

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PURPOSE
To quantify the reduction in staff dose during Digital Subtraction Angiography (DSA) acquisitions after implementation of an image noise reduction algorithm combined with dedicated acquisition settings for peripheral angiography

METHODS
This prospective, single-center study was performed using a monoplane flat detector angiography system (AlluraXper FD20, Philips Healthcare, Best, The Netherlands) equipped with state-of-the-art image processing and reference acquisition settings ("original protocol" with 100% patient dose). On this system a new image noise reduction algorithm combined with dedicated acquisition settings (AlluraClarity, Philips Healthcare, Best, The Netherlands) was installed ("new protocol"). The dedicated acquisition settings included an adaptation of filtration, tube current, pulse duration and detector dose and resulted in 17% patient dose1 (factor 6 patient dose reduction). Two equivalent DSA acquisitions (same projection, contrast injection, FOV) were made for each patient with the two imaging protocols to visualize the aorto-iliac bifurcation and bilateral iliac arteries. An indication of the staff dose rate was measured with three dosimeters (DoseAware, Philips Healthcare, Best, The Netherlands) located at fixed positions.

RESULTS
Complete staff dose information was available for 50 patients (51 subjects enrolled). The mean age was 65.8±10.93 years (15 females and 35 males). Staff dose rate was significantly lower ($p<0.001$) with the new protocol for all dosimeters, with reduction quantified at 70% for DSA acquisitions.

CONCLUSION
The new image noise reduction algorithm combined with dedicated acquisition settings (factor 6 patient dose reduction) can reduce the staff dose during DSA acquisition of approximately 70%.

Note 1 Reference Airkerma at the Interventional Reference Point

Paper Number: **0086**

EVALUATION OF THE PATIENT PEAK SKIN DOSE AND DOSE AREA PRODUCT FROM INTERVENTIONAL CARDIOLOGY PROCEDURES DONE AT THE HEART HOSPITAL IN QATAR.

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Information about the Peak Skin Dose (PSD) and Dose Area product (DAP) from Percutaneous Transluminal Angioplasty (PTCA) and Coronary Angiography (CA) procedures were collected from three interventional cardiology rooms at the Heart Hospital in Qatar. The range of Kvp used in these procedures were 50-125 kv and the fluoroscopy time 0.6 - 52 seconds. For CA procedures, the Dose Area Product values reached 143 Gy.cm2 and the Cumulative Dose values reached 0.752 mGy. On the other hand, the DAP for and CD for PTCA procedures were found to be 143 Gy.cm2 and 2.287 mGy respectively. The relation between the fluoroscopy time and the DAP were also considered.

Paper Number: 0108

EVALUATION OF THE ROBUSTNESS OF SIB IN IMAGE-GUIDED ADAPTIVE RADIOTHERAPY

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In standard IMRT or VMAT treatments planning target volumes (PTV) with increasing doses are treated with different plans consecutively, evaluating the total dose in "Sum Plans". Simultaneous integrated Boosts allow the irradiation of several interlaced planning target volumes in one step, resulting in steeper dose gradients from one target volume to an another plus a significant reduction of dose delivered to adjacent organs at risk (OAR).

Using Redeform, a program developed by Joanneum Resarch in cooperation with our clinic for elastic deformation of either CT datasets and contoured structures, we evaluate the impact of morphological changes and setup errors in SIB, connecting to an already completed study where we evalueted standard VMAT Plans. The patients received one initial planning CT-scan, followed by two CT scans after 3 and 5 weeks of treatment, respectively. Using the same patients data sets, we will be able to connect both studies and compare both methods regarding their invariance concerning morphological variances.

The current study is work in progress, results are not available yet.

Paper Number: 0063

EVALUATION OF THE STABILITY AND UNIFORMITY OF A CONE BEAM CT SYSTEM CT NUMBER-ELECTRON DENSITY CALIBRATION TABLE USED FOR DOSE CALCULATION IN ADAPTIVE RADIOTHERAPY PLANNING

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PURPOSE

The stability and uniformity of the CT number-electron density (CT-ED) calibration table is important in the use of cone beam CT (CBCT) images for adaptive radiotherapy planning. We investigated the stability and uniformity of the CT-ED calibration table over a 1-year period.

METHOD

The CT-ED table was compiled monthly from CBCT images obtained using an Elekta XVI CBCT system and a Gammex model 467 phantom. The phantom was placed at the isocenter and scanned using the CBCT system, with a small field of view (FOV-S, 27 cm diameter) and a medium field of view (FOV-M, 41 cm diameter). Additionally, the phantom was placed at superior/inferior (+/-10 cm) positions relative to the isocenter plane and scanned.

RESULTS

In the isocenter plane, the CT-ED tables for the FOV-S compiled throughout the year were more stable than those compiled for the FOV-M. The maximum standard deviations of the CT numbers used to estimate the electron densities were ~40 for the FOV-S and ~80 for the FOV-M. The differences in the CT-ED tables obtained at the various phantom positions for the FOV-M were larger than those obtained for the FOV-S. For the FOV-M, the mean CT number for the highest electron density at the -10 cm position differed by ~300 from that at the isocenter plane.

DISCUSSION

The CT-ED table for the FOV-S was stable throughout the year. In the case of the FOV-M, CBCT images used in dose calculations should be corrected for variations in the CT-ED table depending on the phantom position.

Paper Number: 0098

EVALUATION OF THREE RECTAL DOSE DETERMINATION METHODS IN GYNECOLOGICAL INTRACAVITARY BRACHYTHERAPY

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BACKGROUND
Intracavitary brachytherapy is an important method of treating cervix and endometrium cancers, where reducing normal-tissue dose may improve the therapeutic ratio. Importantly, the anterior wall of rectum, due to its anatomical position, receives the maximum rectal dose. Choosing an accurate way to determine maximum rectal dose and trying to minimize that can potentially reduce the probability of complications.

MATERIALS AND METHODS
We compared three methods of determining maximum rectal dose in a total of 82 independent applications, all based on orthogonal radiographs and the Manchester system. One method was the ICRU Report 38 recommended reference rectal point. The other two methods used insertion of a marker into the rectum; an inhouse rectal wire or a commercial rectal marker (ShadowForm). The accuracy of patient treatments was checked by comparing the rectal dose calculated using a previously-validated treatment planning system and that measured using patient in-vivo dosimetry with an EDD-5 diode.

RESULTS
Differences between the means of ICRU points and wire marker points (52 applications), as well as between the ICRU points and the ShadowForm marker points (30 applications), were found to be statistically significant ($p<0.001$). In 9 out of 82 applications, the ICRU point did not give the maximum dose. Also, in 11 cases, more than one point on the markers were required to find the maximum rectal-wall dose.

CONCLUSIONS
Our findings support suggestions that ICRU Report 38 requires revision due to various reasons, e.g., practical issues and insufficiency of single-point determination of maximum rectal dose.

Paper Number: 0341

EVALUATION OF X-RAY SPECTRA TRANSMITTED BY SHIELDING MATERIAL USED IN BRAZIL

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The knowledge of attenuation properties of shielding materials is fundamental for evaluation of shielding for medical x-ray imaging facilities X-ray, according to proposed by NCRP 147. However, this shielding evaluation method does not take into account the shape of the transmitted spectra through the shielding materials. Therefore, the present work proposes the evaluation of x-ray spectra transmitted by barite mortars, taking into account the chemical composition of these materials. For this purpose, measurements of primary and transmitted x-ray spectra trough barite mortars plates, with thickness from 5 to 25 mm, were performed using a CdTe detector (Amptek, model XR-100T). The x-ray spectra were produced by a Philips MGC 450 x-ray system. The beam qualities evaluated were: RQR 3, RQR 5, RQR 8 and RQR 10. The air kerma was measured simultaneously using an ionization chamber. The measured spectra were corrected by the detector response, which was studied trough Monte Carlo simulation, using the PENELOPE code. The corrected x-ray spectra were converted in normalized air kerma units (mGy/mAs.keV@1m). In addition, the chemical composition of the barite mortar was studied by x-ray fluorescence (XRF). The results show that the shape of the obtained x-ray spectrum represents adequately the sharp cut on k-edge energy of some elements used on the barite composition. This is a typical characteristics of the attenuator material and beam quality.

Paper Number: 0380

EXPERIENCE WITH PET/MR (18F-CHO) IN PROSTATE: METHODOLOGY, MANUAL REGISTRATION AND EXPECTATIVE WITH HYBRID SYSTEMS.

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Magnetic resonance (MR) and positron emission tomography (PET) have become the primary tool (Gold Standard) in diagnosis, staging and detection of recurrence for prostate cancer (PCa).

Techniques such as spectroscopy (MRS), perfusion (DCE-MR) and diffusion (DWI) have increased the sensitivity and accuracy in PCa diagnosis and have improved the specificity in taking biopsy, however, in tumor staging, metastases in loco-regional peripheral ganglia and the absence of an in vivo MRS QA, PET is one suitable modality to complement the MR.

In the framework of PET-MR review, 19 patients with PCa suspected were studied using anatomical MR techniques, DWI, MRS, DCE-MR (Achieva 1.5 T) with a PET 18F-Cho (Discovery STE) in order to evaluate the complement among the mentioned techniques. In 16 patients have established a correspondence between the MRS/18F-Cho which increases the efficiency of the MRS (discard any influence of patient and peristalsis movements, study time and post-processing), also has been improved the biopsy guidance and the set of techniques (T2, maps and curves of DCE-MR, ADC) that have been used to radiotherapy dose painting.

Changes in gland size close to 10%, complex radiation protection protocols, study time and disadvantages in patient and staff comfort, highlights some of the hybrid PET-MR system benefits, as well, collected background about PET-MR molecular imaging not only shows the advantages of PET/MR methodology, also exposed the benefits of hybrid PET-MR system against PET/MR manual registration.

Paper number 0104

FABRICATION OF A TISSUE CHARACTERIZATION PHANTOM FROM INDIGENOUS MATERIALS FOR COMPUTED TOMOGRAPHY ELECTRON DENSITY CALIBRATION.

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Patient data for treatment planning are usually acquired from computed tomography (CT) scanner. CT scanners use CT numbers, which are in sharp contrast to parameters required by treatment planning systems to account for tissue inhomogeneities within the human body. There is therefore a need to establish the correlation between the CT numbers and the relative electron densities, reDs empirically, by scanning a tissue characterization phantom with CT scanner whose CT number to reD conversion is been determined.

A tissue characterization phantom was constructed from 4 mm perspex (PMMA) sheets and a number of 20 ml plastic laboratory specimen collection containers. The tissue characterization phantom was composed of two cylindrical phantoms designed to mimic the body and head of a standard adult human. The laboratory specimen collection containers were inserted into equally spaced holes arranged along rings on the circular surfaces of the phantoms, which were concentric to a central hole on each of the phantoms. The containers were filled with locally available indigenous materials whose radiological properties (reDs) were determined through attenuation measurement with cobalt 60 beam and CT scanning with two multi-slice CT scanners from different manufacturers. The materials were used to simulate tissues found in the human body.

The reDs of the constructed tissue characterization phantom compared very well with that quoted by the manufacturer of the commercial phantom. The agreement of the reDs is within ± 6.6 % (mean of ± 3.27 %; standard deviation of ± 2.67 %).

Paper Number: 0389

FABRICATION OF AN IODINE-125 PROTOTYPE PLAQUE IN THE RADIATION THERAPY OF OCULAR TUMORS

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^{125}I plaques have been used increasingly in the radiation therapy of ocular tumors. In this study, the plaques adopted for the Collaborative Ocular Melanoma Study (COMS) are designed and made. The plaque diameters were 10mm and 18mm for animal study test and pre-clinical test, respectively. The manufacture of the gold backing and returned edge is similar to COMS model. The returned edge prevents radiation being emitted sideways from the plaque. This reduces the dose to adjacent normal tissues provided the edges are straight and the seeds are placed adjacent to the edge. Ridges within the plaque control the distribution of the radiation. ^{125}I source in the form of seed (4.7mm length and 0.8 mm in diameter) used in this study made by our department, in which the radioactive 125I is adsorbed on the surface at a silver wire contained within the thin titanium capsule. Seed activity is usually about 2-4 mCi which are placed accurately in the plaque in their predetermined position and held in place with a glue and, when dry, covered with a layer of thick silicon solution (as a silastic layer). Loading time is about 1 hour and drying time for acrylic solution is about 24hr in free air. Quality control tests indicated that this plaque can be useful for clinical purposes.

Paper Number: 0223

FEASIBILITY OF USING THE FRACTAL DIMENSION TO ASSESS THE MODULATION COMPLEXITY OF IMRT

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Purpose: To evaluate the feasibility of the fractal dimension (FD) as a metric for the modulation complexity of IMRT.Methods: Uniform sliding window (SW) fields changing the leaf gap (1-50 mm) were utilized. For each SW, five binary images were produced changing the pixel size. The FD was evaluated by the box-counting method. The FDs for each segment and the overall field were evaluated by averaging the five images. Averaged FD (FDa) is the average of the FDs of all the segments, and the standard deviation (SD) of FDa is the between-segment variation of the FDs. A highly modulated field may result in small leaf gaps; therefore the FDa is expected to decrease with increasing modulation complexity.

Results: The FDa decreases with decreases in the width of the leaf gap. The FDas and SDs were 1.964±0.0007 and 1.402±0.0429 for 50 and 1 mm gaps, respectively. The large SDs for small gaps resulted from variability in leaf positions during the SW delivery. For a 1 mm gap, a low FD value of 1.35 was observed at the middle segment where uneven leaf position could be observed visually.

Conclusion: The FDa for smaller leaf gaps, which implies a highly modulated field, was lower. Results in the present study indicate that the FD method would be useful for assessing IMRT complexity. Further studies such as comparison to other metrics and studies of its usefulness in clinical plans are needed.

Paper Number: 0114

FEASIBILITY STUDY OF THERMOLUMINESCENCE SLAB FOR CYBERKNIFE BEAM ALIGNMENT TEST

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QA procedure of CyberKnife beam alignment used to be done using the radiochromic film. The film cannot be used repeatedly therefore there is a problem of running cost. The thermoluminescence dosimeter slab (TL slab) has been developed by Urushiyama et al. The TL slab can be used repeatedly but it has the 2-dimensional sensitivity distribution on a slab.

In this report, the calibration method by comparison with dose distribution measured by ionization chamber was proposed. Furthermore usefulness of the TL slab for CyberKnife beam alignment test was discussed.

The sensitivity correction factor for each region (80 μm by 80 μm) was estimated using the dose distribution by the ionization chamber. The image quality of the TL slab was improved by proposed 2-dimensional sensitivity correction.

Then, the beam alignment was estimated using the radiochromic film and the TL slab and the both results were compared. As a result, it was confirmed that similar alignment displacement can be detected by the film and the TL slab, furthermore the TL slab shows high spatial and contrast resolution.

The proposed simple method was effective for the correction of 2-dimensional sensitivity distribution.

The TL slab shows high spatial and contrast resolution and it could be used for not only alignment test but evaluation of dose distribution. Therefore it is confirmed that the TL slab has feasibility and potential for the CyberKnife QA procedure. And TL slab has the potential to use as 2-dimensional dosimeter. Therefore TL slab is useful to use CyberKnife QA procedure.

Paper Number: 0045

GOLD NANOPARTICLES FOR DUAL X-RAY-OPTICAL IMAGING

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In this advanced and innovative medicine era cancer remains the second most common cause of death in developed countries. Survival of cancer patients depends mostly on successful early diagnosis. At the moment the key method for assessing primary diagnose is X-ray imaging. This method is based on biological tissue X-ray contrastivity and often needs an additional contrast enhancement by exogenous contrast media. Currently used iodine-based contrast agents sometimes leads to toxic effects in kidneys, also have short blood circulation half-life and cannot be functionalized for selective targeting.

These shortcomings can be overcome by gold nanoparticles, which due to the high atomic number of gold, provide much higher X-ray contrast, are non-toxic and offer a wide range of sizes, shapes and surface coating choices. In addition, gold nanoparticles can be functionalised with biologically active ligands, which allow selective accumulation in tumour tissue and leads to specific diagnostics. Furthermore gold nanoparticles in less than 2 nm in size show fluorescent properties and can be used in dual X-ray-Optical imaging.

In our study, we present synthesis method of gold nanoparticles which possess both fluorescence and X-ray absorption properties. We show that these nanoparticles yield sufficient and stable in time fluorescence emission and can be used in biological studies. X-ray study with a live mice confirms that gold nanoparticles provide good X-ray contrast intensity and can be used as an X-ray contrast agent.

Our results suggest that fluorescent gold nanoparticles could be suitable for dual X-ray-Optical imaging and therefore could improve medical diagnostics.

Paper Number: 0138

GROWTH AND TRANSFORMATION OF RADIOTHERAPY TECHNOLOGY IN INDIA: A REVIEW

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OBJECTIVE

India today ranks in the top four economies of the World. Its healthcare delivery system and radiotherapy in particular has witnessed significant growth. A review of Indian radiotherapy technology in the last five decades and its future potential is analysed and discussed.

MATERIALS AND METHODS

At independendence in 1947 Indian radiotherapy was practically nonexistent. In the last century the growth came primarily through cobalt 60 units. In the new millennium India has witnessed significant transformation in radiotherapy technology and almost all state of the art technologies are now available in the country. Chronological and geographical distribution of this growth is studied. Growth of equipment and technologies like 3D CRT, IMRT, IGRT and recent additions like VMAT and SBRT is analysed.

RESULTS AND CONCLUSION

India had its first linear accelerator in 1982, rdiosurgery in 1995, multileaf collimator in 1998 IMRT in 2001, Tomotherapy and Cyberknife in 2010. Linear accelerators grew from 22 in 2002 to 237 (1000% growth) in 2012 and is above 300 units today. New installations are all equipped with features like IMRT, IGRT and VMAT. Brachytherapy too followed the trend. PET-CT and 3T MRI are now used for radiotherapy planning. India, known for its nuclear engineering and quality medical care, will soon have its first proton and particle therapy facility. The growth of radiotherapy technology in India is exponential and with the booming economy and large population base the growth is sustainable. This will help in incremental and disruptive innovations and will make radiotherapy affordable and accessible.

Paper Number: 0355

HAND MONITORING IN FLUORO-CT GUIDED PROCEDURES

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The aim of this work is to assess the dose levels received by the hands of interventional radiologists performing biopsies guided by computed tomography in fluoroscopy mode (fluoro-CT). Attenuation gloves and other protective devices are routinely used in these procedures. However, the radiation dose to the hands may be high with a distribution pattern that is often unknown.

Hand monitoring was performed using home-developed gloves prepared with casings for the insertion of extremity dosemeters at the tip and base of each finger, as well as on the wrist. Left and right hand gloves were prepared. LiF:Mg,Cu,P (TLD-100H) detectors calibrated in terms of Hp(0.07) at the IST Ionizing Radiation Metrology laboratory were used for the dose assessment. The attenuation gloves were worn over the dosemeter gloves with a third sterilised glove on top. The dose assessment was performed in thirty six clinical fluoro-CT procedures, specifically lung biopsies.

Per procedure results show that dose levels may present a large variation. The tips of the index, middle and ring fingers receive the highest dose levels with maximum in the range 31 to 38 mSv. The dose to the wrist is negligible when compared with the dose to the fingers. Dose values for the non-dominant hand are generally much lower than for the dominant hand. Considering all 36 procedures, the total dose to the finger tips varied between 130 and 264 mSv, approaching the annual dose limits.

This project is funded by Fundação para a Ciência e Tecnologia, ref. PTDC/SAU-ENB/115792/2009.

Paper Number: 0205

HOSPITAL-BASED DOSE SURVEY, AN IMPETUS TO A NATIONAL DIAGNOSTIC REFERENCE LEVEL IN CHEST X-RAY EXAMINATIONS

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References have cited that the largest radiation dose received by humans come from diagnostic radiology procedures. Ideally, doses should be made as low as possible with the end of not losing the value of diagnosis. The establishment of Diagnostic Reference Levels (DRLs) helped address the issue of high doses from diagnostic radiology. Currently, there is no established DRLs in the Philippines. Our country only adopts what the International Atomic Energy Agency (IAEA) provides. This study aimed to determine doses received by adult patients undergoing chest posteroanterior (PA) x-ray examination in a local hospital. It also aimed to provide an estimate of entrance surface dose for chest PA as a later basis for establishing DRLs in the country. The results revealed a dose estimate of 0.15±0.06 mGy which is lower than the reference levels set by two international organizations: (1) European Commission (EC); and (2) IAEA. It is also relatively lower than the doses measured in similar studies in other countries. This study gives an indication of a good radiography practice in the concerned hospital. It is recommended that the data in this study along with other related studies be used in establising national DRLs.

Paper Number: 0358

HOW MUCH DOSE DOES THE CONTRALATERAL BREAST RECEIVE USING BREAST EXTERNAL BEAM RT TECHNIQUES?

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The use of ionizing radiation to treat breast lesions with whole breast irradiation (WBI) is commonly referred to as increasing the probability of developing secondary diseases, particularly secondary contralateral breast (CLB) cancer, especially in young women.

The CLB after primary breast irradiation using conventional techniques with photon therapy using a linear accelerator may receive average doses greater than 2 Gy, increasing the concern about radiogenic contralateral breast tumors. The quantification of the dose received by the CLB after a 50 Gy (2Gy/fraction) treatment was performed in our study comparing 3 IMRT techniques using Monte Carlo simulations of a VARIAN Trilogy linear accelerator (previously modeled and validated).

According to our findings, the beam arrangement chosen to irradiate the breast to treat is the most significant factor affecting significantly the CLB dose. Tangential (with medial and lateral fields) techniques are expected to decrease the dose in the CLB but may compromise the adequate irradiation of the target volume, either for forward planning (V5Gy estimated in 2.48±1.63% and V2Gy in 10.81±3.62% of the CLB volume) or inverse planning (V5Gy in 3.29 ± 1.42% and V2Gy in 13.53 ± 5.01% of the CLB volume). Moreover, non-tangential fields do increase the dose in the CLB (estimated V5Gy 22.17±19.07% and V2Gy 39.69±37.72%) but may provide better target conformation and lower percentage of high doses to the heart (in case of left breast irradiation) and ipsilateral lung.

Therefore, tangential IMRT techniques are recommended against other beam arrangements in WBI, for young breast cancer women.

Paper Number: 0003

IDENTIFICATION AND MITIGATION OF NON RANDOM ERRORS DURING HANDLING AND HUMAN ADMINISTRATION OF RADIONUCLIDES

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Consequential outcome of non random errors in handling and administration of radionuclides include administering a radionuclide either for diagnostic or therapeutic purposes to a wrong patient or wrong radiopaharmaceutical/activity to a patient.Such error events may also include incorrect patient identification,administration of radionuclide through wrong route and to pregnant/lactating women.Incorrectly administered 370 MBq of radionuclide I-131 to a wrong patient results in an absorbed dose of about 8Gy to thyroid.The dose reduction methodologies include expedious removal of administered activity through gastric lavage,emesis,laxatives and accelerated excretion by judicious use of diuresis and hydration.In addition the use of blocking agents help reducing absorbed dose to thyroid,salivary gland and stomach.In other instances a radiopharmaceutical Tc-99m-DTPA used for renal imaging was administered to a patient scheduled for skeletal imaging and in such situation even though the attempts were made to reduce the absorbed dose to patient but repeat of the study could not be prevented.Incorrect rout of administration for example Tc-99m DTPA administered intravenously instead of its aerosol form are frequent errors often observed and for which repeat of the study is unavoidable.In another example a lactating women administered with 140 MBq of I-131 results in an absorbed dose of 250 Gy to thyroid of the baby necessitating the baby to be put on thyroid substitution therapy for life long.Major factors identified for such errors include communication gap, patient overload,absence of local rules,undefined responsibilities and inadequate training as well as knowledge.

Paper Number: 0370

IDENTIFICATION OF PATIENTS REQUIRING FOLLOW-UP BASED ON MAXIMUM SKIN DOSE ESTIMATED WITH RADIOCHROMIC FILM IN INTERVENTIONAL CARDIOLOGY PROCEDURES

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There is a wide variety of interventional procedures with a high complexity that may result in high radiation doses on the patient's skin. The kerma-area product (KAP), the fluoroscopy time and cumulative air kerma (CAK) monitoring are recommended in these procedures in order to following up the patients. These parameters displayed on the equipment console do not correspond to the real maximum skin dose (MSD). The skin dose can be estimated with radiochromic films, since this way it is possible to consider the scattered radiation and the overlap of the irradiation fields. The aim of this study is to identify patients with risk of damage to the skin, using the correlation between MSD obtained with radiochromic film (Gafchromic XR-RV2) and the value of KAP in angioplasty and cardiac catheterization. KAP and CAK values were recorded in 770 procedures and MSD were estimated in 24 cardiac procedures performed in the Philips Allura FD10 equipment. The results showed that a correlation between MSD and KAP exists ($R^2 = 0.76$) and that through this estimation it is possible to identify 34 patients with risk of skin damage based on the values suggested in the publication NCRP 168. The value of KAP in the equipment console shall be used for monitoring the dose, and when associated with MSD allows to identify patients who should be followed-up, since the cumulative dose might be effectively risky in a certain skin area. Solely fluoroscopy time records are not able to associate the dose with risk.

Paper Number: 0154

IMAGE QUALITY AND RADIATION DOSE IN PROPAGATION-BASED PHASE CONTRAST MAMMOGRAPHY: A PHANTOM STUDY

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Within a research project funded by INFN, we are investigating image quality and the related radiation dose in absorption based and phase-contrast based x-ray mammography, using the in-line propagation based geometry. In particular, we study the possible reduction in absorbed dose at high photon energy in phase maps of breast phantoms, with respect to conventional absorption based imaging at low energy. The experimental system is based on a micro-focus X-ray tube with a 7 μm focal spot size (W anode, 1.58 mm Al filter) and a 50-mm-pitch flat panel detector.

Mammographic images of a 50% glandular fraction breast phantom (5-cm thick) at different mean glandular dose (MGD) were acquired at varying kilovoltages (40 to 100 kVp), either with the phantom in contact with the detector (absorption image) or in a geometry with an image magnification ~ 2 (phase contrast image). The phantom contains masses and microcalcifications details. The phase maps were retrieved with the software ANKAphase assuming proportionality between index decrement δ and absorption index β of breast tissue and using transport if intensity equation model. A comparison between the two modalities in images containing an 8-mm diameter mass will be presented in terms of contrast, contrast-to-noise ratio and signal-to-noise ratio, as a function of MGD, at varying kilovoltages.

Paper Number: 0042

IMPLEMENTATION OF ACCREDITATION PROGRAMME FOR MEDICAL PHYSICISTS IN BANGLADESH

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INTRODUCTION

Medical physicists working in hospitals need to be clinically trained. This trend is already prevalent in developed countries. IAEA has developed guide-books for clinical training of medical physicists who specialize in Nuclear Medicine, Radiation Oncology and Diagnostic Radiology.

Bangladesh was the first RCA member to implement clinical training programme based on the guide-book for medical physicists specializing in nuclear medicine.

OBJECTIVES

Establish an infrastructure to operate an independent and sustainable accreditation programme that is nationally recognized as well as test out the effectiveness of the guide-book in providing clinical training to medical physicists specializing in nuclear medicine.

IMPLEMENTATION

Governance structure, as recommended in guide books was implemented. Bangladesh Atomic Energy Commission took the overall responsibility for the programme as the National Responsible Authority. An 8 member National Steering Committee was formed. A National Program Coordinator was appointed and Bangladesh Medical Physics Association agreed to be the Professional Body for accreditation.

The 2 year pilot to test the effectiveness of the guidebook was successfully finished.

CONCLUSION

The Clinical Training for medical physicists specializing in nuclear medicine improved the capabilities of the Residents. A sustainable accreditation structure is in place. After running similar programme for radiation oncology and diagnostic radiology, the challenge would be to establish and sustain a National Accreditation Programme for Medical Physicists' specializing in Nuclear Medicine, Radiation Oncology and Diagnostic Radiology.

Paper Number: 0210

IMPLEMENTATION OF EMERALD TRAINING MODULES IN BRAZIL

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A research cooperation program was established between the Physics Institute of the University of São Paulo and the King´s College of London to conduct the translation, adaptation and update of the X-Ray Diagnostic Radiology training module of the Emerald Program (www.emerald2.eu/cd/Emerald2/). The Program teaching material is divided in ten topics: General Principles of Radiation Protection, General Principles of Diagnostic Radiology Quality Control, X-ray Dosimetry and Patient Dosimetry, Radiological Image Parameters, X-ray Tube and Generator, Radiographic Equipment, X-ray Films/screen and Laboratory, Fluoroscopic Equipment, Digital Image and CT Equipment, and Basics of Shielding in Diagnostic Radiology. The referred work, besides the translation of the texts into Portuguese, comprised the review of the teaching material. It was decided to update some of the training tasks and add more information related to current topics such as digital X-ray imaging modalities, multi-slice CT and tomosynthesis. These new additions will also be available in English. The translated or written texts have been submitted to a cross-reviewing process by the co-authors in order to standardize the language. Moreover, national radiological protection recommendations were included to assist the users of the teaching material with the Brazilian rules of radiation safety and quality control in X-ray medical applications. The material will be submitted to a validation process by means of a critical analysis by experts in MP education and finally to a pilot dissemination before making available to other users. Further assessment procedures were planned in London and São Paulo aiming to evaluate and disseminate the final product.

Paper Number: 0076

IMPLEMENTING STEREOTACTIC TREATMENTS FOR EARLY PERIPHERAL LUNG CANCERS: THE PHYSICS PERSPECTIVE

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The provision of stereotactic treatments for early peripheral lung cancers was implemented in late 2012. Here we discuss our experiences and how the pathway through pre-treatment, planning and physics has been optimised using knowledge gained from treating our first ten patients.

We discuss how the national guidelines have been implemented within our department and how the planning process has been adapted to conform with these. In particular we show how uncertainties in small field dosimetry have led to modifications of the planning process and discuss how this may develop for future treatments.

The national guidelines recommend the use of 4DCT for all patients. This is not suitable for all patients and we examine the implications of this on the delineation of tumours and the planning process. We show how our departmental processes have been adapted to accommodate the difficulties this presents.

A method for performing patient specific quality assurance was developed and data from the first ten patients is presented which demonstrate that the delivered doses are within 2% of the planned values.

This work will provide useful information for other centres considering offering the provision of stereotactic lung treatments.

Paper number **0161**

IMPROVED MICROFOCUS X-RAY IMAGING TECHNIQUE FOR EVALUATING INTERNAL GEOMETRY OF BRACHYTHERAPY SEEDS

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The internal geometry of brachytherapy seeds should be precisely evaluated for obtaining dosimetric parameters and functions. However, whereas the parameters are usually provided by manufactures and vendors, a precise method for evaluating the internal geometry has not yet been developed. Therefore, we have developed a novel method based on a microfocus X-ray imaging technique for evaluating the internal geometry of brachytherapy seeds. In a previous study, image quality was limited by image distortion owing to the use of an image intensifier detector. Thus, to improve image quality and measurement precision, we introduced a new microfocus X-ray imaging system with a flat panel detector system. A general-purpose X-ray chart was used to evaluate the image distortion quantitatively and visually. X-ray projection images were taken for two kinds of seed models, model 6711 (GE Healthcare/Oncura) and STM1251 (Bard), which have been used for brachytherapy treatments of prostate cancer with LDR permanent seeds. As a result, we found that the new imaging system can reduce the measurement uncertainty when using projection X-ray images. The maximum image distortion in the new system with a flat panel detector was negligibly small, whereas the distortion in the previous system was up to 2 pixels at the image corners. Further, the reduction in the focal spot size of an X-ray tube from 1.0 to 0.4 μm was found to improve the image quality. The microfocus X-ray imaging technique was probed to be a promising tool for visual and quantitative evaluation of the internal geometry of seeds.

Paper Number: 0220

IMPROVING THE MONTE CARLO SIMULATION ACCURACY FOR RADIOACTIVATION IN PROTON THERAPY WITH ANTI-SYMMETRIZED MOLECULAR DYNAMICS.

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PURPOSE

In the studies concerning particle therapy, the simulations based on quantum molecular dynamics (QMD) model are frequently used. For improving the nuclear reaction model, we try to apply the anti-symmetrized molecular dynamics (AMD) model.

METHODS AND MATERIALS

The nuclear reaction process has roughly two phases.

One is dynamic process, where nucleus in target is broken into pieces by collision with incident particle and the fragments are unstable and they decay to stable state. The latter phenomenon is called evaporation process.

Since AMD and QMD can describe the former process only, we used generalized evaporation model for the latter.

With both models, we simulated proton induced reactions and calculated the cross sections on 12C and 16O target in the incident energies between 20 MeV and 200 MeV every 20 MeV.

Finally, we compared their results of simulations with measured data and investigated their accuracy.

RESULTS

For the nuclear reactions, 12C(p,x)11C, 12C(p,x)10Be, 16O(p,x)10Be, the results of AMD showed equal accuracy to QMD. These relative error to measurements were (0.15/0.94), (0.27/1.45), (1.00/0.99), (AMD/QMD).

On the other hand for 12C(p,x)4He reaction, AMD was better than QMD, (0.57/6.65).

CONCLUSION

Compared with QMD model, in some nucleus reactions, AMD model gives the equivalent accuracy or more properly results. AMD has a probability of improving the accuracy of proton therapy simulation.

Paper Number: 0216

INCREASING EMPHASIS ON APPROPRIATENESS OF X-RAY IMAGING AS A MAJOR ELEMENT OF PATIENT DOSE REDUCTION PROGRAMMES

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Justification, optimisation and dose limits are sometimes described as the three pillars of radiation protection. Arguably there may have been a greater focus in some circles on optimisation and dose limitation but there is now increasing recognition of the major contribution to patient dose reduction programmes that can be achieved by attention to justification.

The IAEA triple A triptych: awareness, appropriateness and audit has entered the radiation protection lexicon. Increasing attention is being given to appropriateness criteria, to ensure that those referred for radiological examinations really need them. Evolving referral criteria for X-ray examinations, such as the UK RCR, US, Canadian, Australian and French guidelines, have been introduced / adapted in a number of countries, with moves towards global standards within a local context. They can inform clinical pathways and computerised decision support systems, providing guidance to clinicians on appropriate diagnostic strategies and helping to identify appropriate imaging procedures for individual patients.

There is widespread anecdotal and some published evidence that a high proportion of X-ray examinations are unnecessary. When considering imaging options clinicians are encouraged to ask themselves whether this will affect the patient management. In practice there are many influences which impact upon decisions to perform an X-ray examination.

This presentation will consider such influences and suggest ways to improve referral practice, with a view to reducing unnecessary use of X-ray imaging. This has significant potential to reduce population doses and encourage appropriate use of resources. Scientific evidence-based approaches, harnessing appropriate technology, can greatly assist this process.

Paper Number: 0339

INFLUENCE OF THE ORGAN CT UNITS ASSIGNMENT FOR MRI ONLY BASED EXTERNAL RADIOTHERAPY TREATMENT PLANNING

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Recently, in order to eliminate the necessity of CT in radiotherapy planning, with all the advantages to the workflow and to the patient, there has been an attempt to use MRI only, keeping the same planning and treatment delivery quality. Some methodologies have been used to accomplish this task: CT units assignment to each organ and internal structures, or simply only the bone segmentation and appropriate CT units assignment to all the other structures. In this study, the TPS (Varian Eclipse) is not able of making calculations directly on MRI DICOM images. There is thus the need to camouflage the CT into MRI by changing the DICOM header. Afterwards, one can segment the structures on the camouflaged MRI and assign a suitable CT unit distribution. One has tried to evaluate how much differentiation of the CT units from structure to structure is necessary to accomplish a true CT like based plan quality. One began with a brain treatment planning obtained with a true CT, then changed the structures to uniform CT units distribution and re-calculated the plan maintaining all the previously delineated volumes. Both plans were compared in terms of mean dose. One has also evaluated the two plans using two different algorithms (AAA and PBC). The dose change of the true CT into the modified one was less than 0.5% in all structures and negligible at the PTV (~0.1%) and slightly increased in the AAA algorithm, indicating that organ differentiation is not critical for MRI only treatment planning.

Paper Number: 0342

INTELLIGENT MARGINS FOR SBRT BASED ON FIDUCIAL TRACKING

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Cyberknife SBRT for target motion due to breathing is often based on fiducial tracking using the Synchrony system. The basic assumption of this approach is a fixed bond between fiducials and target. This assumption may be corrupted for one or more fiducials during the breathing cycle due to target deformation or a lack of correlation between fiducial and target position. In order to deal with this we acquire an extra narrow inspiration breath hold CT together with a standard planning end-expiration breath hold (EEBH) CT. G/CTV and fiducials are then contoured on both CTs and exported for analysis using a MATLAB based script.

The script allows for the quantitative assessment of various configurations of fiducials in terms of the extra target volume needed to avoid underdose during the breathing cycle and the associated fiducial rigid body error. In addition, it simulates tracking with and without correcting for rotations. A graphical representation of the original G/CTV(EEBH) with the recommended additional anisotropic margins for particular combination of fiducials is then generated.

For little extra work the method provides useful information in terms of fiducial handling and the estimated impact of decisions made on set. All of this aids in creating “intelligent margins” to account for variable geometry between target and fiducials, including target deformation, based on individual patient/target/fiducials data. Not only does this practice spare healthy tissue by eliminating the need for general isotropic margins, it represents better target definition due to double target contouring and correction for inaccuracies of surrogate tracking.

Paper number **0026**

INTENSITY MODULATED RADIATION THERAPY IN ORGAN CONFINED / LOCALLY ADVANCED PROSTATE CANCER.

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PURPOSE
To present our experience of IMRT for prostate cancer in terms of dose escalation and rectal toxicity.

BACKGROUND
Definitive conventional radiotherapy was routinely given in organ confined/locally advanced prostate cancer. IMRT is new modality where more conformal dose delivery is possible with dose escalation due to lesser rectal toxicity. We have explored toxicity of IMRT in prostate cancer.

MATERIAL & METHODS
From April 2010 to May 2012, 09 patients with biopsy proven non metastatic adenocarcinoma prostate at Shifa International Hospital were included in study. We reviewed the medical records and collected the data to determine acute toxicity of pelvic IMRT. Median age of patients was 71.5 years (range 63-82 years). MRI pelvis, CT abdomen and bone scan were done for staging. Fiducial marker & CT planning was done with empty rectum, full bladder and precise planning system was used.

RESULT
IMRT doses ranging from 74Gy to 82.9 Gy were delivered to prostate. Rectal doses ranging from 40 Gy to 45 Gy of 50% volume and 57 to 68 GY of <15% volume. Toxicity were scored according to NCI.CTC. Main toxicities were dysuria, nocturia, diarrhea

CONCLUSION
IMRT for prostate cancer helps safe dose escalation by reducing rectal toxicity and should be considered for localized and locally advanced prostate cancer.

Paper Number: 0262

INTENSITY MODULATED RADIATION TREATMENTS PATIENT SPECIFIC QUALITY CONTROL - STATIC 2D VERSUS 2D PLUS MOTION TOOLS

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Patient specific pre-treatment plan verification is a matter of special concern in IMRT and VMAT [1]. Furthermore, the measurement system and evaluation criteria are critical due to the existence of high gradient dose regions and the possibility of accidental critical organs irradiation in case of TPS miscalculation or hardware malfunction.

This work aims to compare the results between a static 2D array and a 2D plus motion (4D) measurement system. More than thirty IMRT and VMAT treatment plans were evaluated using the 2D method – PTW Octavius®I for IMRT and Octavius®II for VMAT – and using the 2D plus motion method – PTW Octavius®4D. The results were analysed using the gamma function. Using the same tolerance levels, it was observed a lower passing rate in the 2D plus motion approach, indicating that this methodology is more sensitive to differences between TPS dose distributions and verification measurements. This is certainly due to the increase in the number of measuring points and the non-existence of parallel irradiation of the 2D matrix, which has been clearly solved by the 2D plus motion approach. However, the measured dose distribution in the rotating plane is used to calculate a second dose distribution to be compared with the TPS dose distribution. The accuracy of this dose calculation might be subject of further debate and its influence in the gamma function tolerance levels is still to be determined [2, 3].

[1] ICRU Report 83 (2010)

[2] IFMBE Proceedings 25/1 (2009) 248

[3] Med. Phys. 40, (2013) 031702

Paper number 0258

INTERNATIONAL TRAINING CENTER FOR CONTINUING PROFESSIONAL DEVELOPMENT IN MEDICAL RADIATION PHYSICS FOR THE CIS REGION

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To bridge the gap in radiation oncology the urgent measures are taken on procurement of cutting-edge equipment and innovative technologies for radiation oncology in the Commonwealth of Independent States. There's a clear understanding that shortages of equipment and qualified medical physics staff are strong constraints to safe delivery of advanced cancer treatment.

The education of medical physicists is provided by the International Training center on medical physics and radiation oncology organized by the Association of medical physicists in Russia on the clinical base of N.N.Blokhin Russian Cancer Research Center. It offers the postgraduate education in medical physics for the Russian speaking specialists under the IAEA Technical Cooperation Project RER/6/025 - Building Capacity for Medical Physics in Radiation Oncology at the International Training Centre for the CIS Region. The CPD program is structured in 4 modules: Dosimetry and Quality Assurance of External Beam Radiotherapy, Commissioning and Quality Assurance for Radiotherapy Treatment Planning Systems, Basic course for Medical Physicists and Medical physics for the university teachers and healthcare managers. The teaching is done in Russian by qualified and skilled specialists. The faculty consists of 50 professors with clinical experience and technical expertise. Each course consists of lectures and hands-on training. 100 specialists will be annually trained from the CIS countries. The education, travel, accommodation and meals expenses are fully covered by the IAEA and Russian Government. The distinctive features of the two or four week courses are: teaching in Russian and hospital-based training which both increase the educational efficiency in medical physics.

Paper Number: 0206

INTERNET-BASED INFORMATION EXCHANGE IN GLOBALIZATION OF MODERN MEDICAL PHYSICS

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Modern Medical Physics becomes more international than ever before. In addition to knowledge of national regulations, legal requirements, and methodology, Medical Physicists are required to be familiar with scientific publications, materials of international conferences, international studies and recommendations, as well as education and training requirements for Medical Physicists. All this information becomes more and more global. Medical Physics communities in different countries and schools are looking at the same sources of information and are trying to adopt a universal approach to the problems they face. In addition to scientific and practical knowledge, legal requirements in different countries become more and more correlated with each other, as well as educational and licensing requirements. Medical Physics needs wide international collaboration for its further development.

To satisfy growing need in international information exchange, American Association of Physicists in Medicine is creating a new subcommittee - International Information Subcommittee. Its charge will be significant expansion of International section of the AAPM website. We plan to provide systematic information about International and National Medical Physics Societies, legal and licensing requirements, methodology of work, materials of International conferences, schools, and workshops, links to relevant information and even information about job and residency openings. We are looking forward to collaboration with National and International Medical Physics organizations, licensing and regulatory authorities, scientific and educational committees and all other organizations which can help to make this task more comprehensive and more valuable. We are interested in wide collaboration with National Societies and International organizations in International Information Exchange.

Paper Number: 0381

INTESTINAL FLOW MEASUREMENTS: EFFECT OF FOOD FORMULATION

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The increasing incidence of dietary related chronic diseases such as obesity and diabetes, motives the study of phenomena occurring during digestion and absorption processes in the gastrointestinal tract. Although the last developments in flow visualization imaging techniques enable a better understanding of gastrointestinal motor functions, unanswered questions remain, especially regarding the small intestine in which assessment of flow is difficult. The aim of this work was to model processes underway in flow and digestion to understand phenomena occurring during food digestion. Intestinal flow and mixing processes were measured in vivo and simulated in vitro using a pneumatic Small Intestine Model (SIM). Of particular interest was to study the effect that food formulation has on the intestinal wall movements (peristalsis). Results showed the effect of food formulation on intestinal wall motion. Flow visualization techniques used for studying flow paths in the SIM showed that this in vitro model reproduces the characteristic flow events found in the small intestine in vivo. Overall, this research provides insights into the role of wall movements on enhancing absorption of active components on the course of digestion processes. The experimental data also give information for the design and development of further in vitro models to predict and simulate the action of structured food on the delay of absorption processes in the small intestine.

Paper Number: 0145

INVESTIGATION INTO CHANGE OF CLINICAL IMAGING PROCESSING IN FFDM

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FFDM Image quality is evaluated using pre-processed images to characterise performance of the digital detector. The effect of clinical image processing, established from user preference, can be overlooked. This investigation into a recent change in image quality processing was undertaken to quantify the perceived ‘improvement'.

Images of CDMAM and TORMAM test objects were obtained from a Siemens Inspiration FFDM unit and reconstructed using two clinical processing algorithms: the standard algorithm and a high contrast algorithm. The latter was installed because radiologists preferred the images. Sixteen CDMAM and three TORMAM images per processing algorithm were acquired. CDMAM images were auto-analysed using established software. TORMAM images were scored by three experienced readers. SNR and CNR were established at 4.5cm PMMA for both clinical processing algorithms.

CDMAM high_contrast images provided statistically significant improvement in threshold detection for the smallest detail diameters 0.08 and 0.1mm. Processed SNR and CNR were reduced in value by 49% and 5.7% respectively with change to high_contrast algorithm. TORMAM evaluation did not indicate any change to subjective Image Quality with mean scores of 86.8±2.7 (1s.d.) and 87.7±3.2 for Standard and High_contrast algorithms respectively.

CONCLUSIONS: SNR is highly sensitive to image processing changes and is therefore a useful quantitative tool for evaluation of detector performance and clinical image processing. CDMAM proved sensitive to changes in clinical image quality for small details in this investigation. TORMAM detected no significant difference between the processed images. TORMAM did confirm acceptability of high_contrast image quality and is well understood by the user.

Paper Number: 0188

INVESTIGATION OF BREMSSTRAHLUNG RADIATION FOR 4 TO 12 MEV ELECTRON AND POSITRON BEAM

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Radiotherapy with external high energy photon beams are the most common radiotherapy modality. In radiation therapy, the absorbed dose at the specific point in a patient should be known with an overall uncertainty of 3 %. Therefore, the knowledge of the energy spectra and angular distribution of photon beams at the point of application is essential for accurate dose calculations. The 4 to 12 MeV photon has widely used for medical and nuclear applications. Therefore using 4 to 12 MeV electron and positron beam, the angular distribution of generated bremsstrahlung and its energy spectrum from different thicknesses of materials has been calculated using EGSnrc based Monte Carlo BEAMnrc user code. The inputs for simulation are defined as the beam diameter 0.2 cm, beam direction along the Z axis and beam allowed to fall on the cylindrical target perpendicularly. The thickness of the Al, Cu, bone and W cylinder was varied from 0.1% to 150% of RCSDA. An energy cut was set to be 511 keV and 100 keV for electron and photon. It has been observed from the simulated results that as the e-γ target thickness increases, the bremsstrahlung fluence also increases till certain thickness and then decreases with increase in the thickness of target. Moreover, the bremsstrahlung fluence observed to be more in the forward direction. The data generated in this paper can be used as a right hand data for the researchers working in the field of medical, nuclear and accelerator physics.

Paper Number: 0176

INVESTIGATION OF TISSUE ELASTICITY MEASUREMENT USING SHEAR WAVE ULTRASOUND ELASTOGRAPHY: A PHANTOM STUDY

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INTRODUCTION AND OBJECTIVES

Shear wave elastrography (SWE) is a new emerging technique using ultrafast ultrasound to measure tissue elasticity in a selected volume of the human body. This study aimed to verify the accuracy of SWE measurement in an elasticity phantom.

MATERIALS AND METHODS

A homogenous elasticity phantom (background) was constructed using 80 g of gelatin (LB250, Rousselot Co, China) dissolved in 800 ml of water. Five spherical masses [constructed using different amount of gelatin (8 to 24 g with 4 g increasing step) mixed with 0.5 g of CaCO3 and 150 ml of water] incorporated into the phantom to represent different stiffness of lesions. The lesions elasticity was measured using a shear wave ultrasound scanner (Aix-plorer, SuperSonic Imagine, France) and a material microtester (model 5848, Instron Co, USA). The elasticity values were then compared.

RESULTS

The elasticity (lesions 1 to 5) measured by the SWE were 15.967±0.503, 59.067±1.002, 82.033±1.795, 108.767±2.684 and 125.433±1.904 kPa, respectively. Whereas the elasticity measured by the material microtester were 8.514, 7.769, 45.760, 85.200 and 117.617 kPa, respectively. Although there was significant difference ($p<0.05$) between the two data sets, there was a strong correlation between the two. Our results revealed that the SWE measurement overestimate the tissue elasticity by 7 to 51 kPa.

CONCLUSION

The tissue elasticity measured by the SWE method appeared to be overestimated compared to the gold standard. Further research need to be carried out to determine the offset from the SWE measurement and to account for these differences.

Paper Number: 0362

LUNG VMAT SABR USING THE ELEKTA AGILITY 160-LEAF MLC AND FFF BEAMS

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VMAT has been shown to reduce overall treatment time for lung SABR compared to conformal techniques. Flattening-Filter Free (FFF) beams provide increased dose-rates and may further improve delivery times. In addition, FFF plan quality requires analysis relative to standard (flattened) beam plans.

5 lung SABR patients were planned for 55Gy/5 fractions. VMAT plans with standard (6X) and FFF (6XFFF) 6MV beams were compared. Elekta FFF beams are re-tuned to match the PDD at 10 cm depth in water (10 x 10 field) to the standard beam. All planning was on Monaco v3.3 for delivery on a Synergy Linac with the relatively fast Agility head. The isocentre was positioned at patient mid-line in all cases. Treatment deliveries were verified using the Delta4 and point dose measurements in a CIRS lung phantom and were compared for delivery time, gamma index and PTV point dose.

Plan quality was comparable between 6X and 6XFFF beams and plans were produced in a similar time-frame. The VMAT prescription class solution used clinically for 6X treatments was suitable for 6XFFF. Dose deliveries were acceptable within usual clinical tolerances: ≥95% of points passing 3%/3mm gamma analysis and PTV point dose within 2%. Treatment delivery times for the 6XFFF plans were approximately 1min faster than for 6X.

Thus FFF beam plans for lung VMAT SABR are comparable to those using standard beams, but with decreased delivery times. The VMAT optimisation parameters were similar to those used for flattened beams and therefore require minimal changes to the established planning process.

Paper Number: 0107

MAGNETIC NANOTHERAPEUTICS OF GUERIN CARCINOMA

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The aim of the paper is to analyze the antitumor effects of magnetic nanotherapeutics initiated by non-uniform constant magnetic and electromagnetic fields on experimental tumor models of Guerin carcinoma. The animal tumors were irradiated locally with non-uniform constant magnetic and electromagnetic fields by apparatus MagTherm®. Animals were treated by doxorubicin (DOXO) in the dose 1.5 mg/kg and magnetic nanocomplexes (MNC) in the dose 3.5 mg/kg. The temperature was increased up to 39.1°C after 15 min of irradiation (EI). For animals with Guerin carcinoma it has been shown, that local irradiation by spatially inhomogeneous constant magnetic and variable electromagnetic fields and simultaneous administration of magneto-mechano-chemically synthesized magnetic nanocomplex (MNC) had a greater antitumor effect compared with the administration of conventional doxorubicin and compared with the administration of magneto-mechano-chemically synthesized magnetic nanocomplex (MNC) only. We suggest that the non-uniform magnetic and electromagnetic fields within tumor cells induced electromechanical forces at the daughter cells that interfere with orientation and induced dielectrophoresis in the spindle tubulin of tumor cells.

Paper Number: 0037

MAGNETIC RESONANCE IMAGING OF THE BUTTOCKS TO DETERMINE SOFT TISSUE DEFORMATION DURING SITTING

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Sitting for extended periods has the potential to compromise tissue health for individuals with mobility impairments due to spinal cord injury. Reduced mobility and impaired sensation combine to make tissue breakdown and pressure ulcer development an economic and psychologically costly complication of wheelchair use. The aim of this study was to use magnetic resonance Imaging (MR) to describe the 3-dimensional response on an individual's buttocks to sitting. Volunteers were imaged whilst seated in a FONAR 0.6 T Upright MR system. Sagittal, T1-weighted Fast Spin Echo, 3 mm slices were acquired with the individual seated on a custom wheelchair cushion with a cut out beneath the buttocks (unloaded), and seated on a commercially available foam cushion (loaded). MR images were analysed to demonstrate fat and muscle deformation and bone and muscle were segmented to enable 3D rendering of muscle deformation in the unloaded and loaded situations. Linear measurements indicated a marked decrease in muscle thickness under the ischial tuberosity during loaded sitting. This change in thickness resulted from a combination of muscle displacement and distortion as evidenced by the 3D rendering. The gluteus and hamstrings overlapped beneath the pelvis in an unloaded condition, enveloping the ischial tuberosity. But the overlap changed under load. The hamstrings moved anteriorly, while the gluteus moved posterior-laterally. Under load, neither muscle was directly beneath the apex of the ischial tuberosity. Furthermore, there was a change in muscle shape, particularly posterior to the peak of the ischial tuberosity.

Paper Number: 0326

MEDICAL EQUIPMENT QA FROM CLINICAL PATIENT DATA, BY USING DATA CONSISTENCY AND FAILURE MODE PATTERNS: AN EXAMPLE FROM GAMMA CAMERA IMAGING

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Quality Assurance (QA) procedures are part of daily practice in Medical Imaging. Major failures during clinical imaging will be seen by the operator, but less obvious faults may occur and not be observed. We illustrate the principle of the use of patient images to monitor equipment performance, with gamma camera imaging as an example. The basis is to find data which can be cross-compared within a study for consistency. For dual-headed gamma cameras the two heads provide such comparative data in emission tomography, and single headed cameras produce comparative data when used in whole body scanning. This study aims to determine the conditions under which a 5 % 20 mm diameter photo-multiplier sized uniformity defect in a gamma camera head can be identified from patient data. The method used was to create artificial defects up to 5 % using absorber material on one head during SPECT imaging of a non-uniform cylindrical phantom, and to apply comparative image analysis. Example patient data was examined to identify the count density from summed SPECT bone images, and to predict the sensitivity of the technique from this. The results showed that 5 % photo-multiplier sized non-uniformity can be identified on phantom data, with similar performance from clinical bone SPECT images. In conclusion, the study shows that patient data can provide almost continuous QA checking for gamma cameras, provided that the imaging system provides data that should be self-consistent, and assisted by analysing the images to reflect the common failure modes of the equipment.

Paper Number: 0333

MEDICAL PHYSICISTS IN AFRICA - CONSOLIDATING THE DATABASE.

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The dearth of complete database of the Medical Physicists in the African continent has been identified as one of the urgent assignment that needs to be tackled by the FAMPO (Federation of African Medical Physics Organisations) Executive committee members (ExCom).

A survey conducted in the region in the course of executing the IAEA inter-regional project INT/6/054 - Strengthening Medical Physics in Radiation Medicine - tangentially provided some information in this regard but this is not sufficient.

The FAMPO ExCom seized the opportunity of the Project Coordinators Meeting (PCM) of the two International Atomic Energy Agency (IAEA) regional medical physics projects in Africa (RAF/6/038 - Promoting Regional and National Quality Assurance Programmes for Medical Physics in Nuclear Medicine and RAF/6/044 - Strengthening Medical Physics in Support of Cancer Management - Phase II) in 2012 to launch a data collection effort meant to address this dearth of information.

This presentation will highlight the progress made so far towards achieving a consolidated data base for the entire region. This will also provide information for an ongoing initiative of the IOMP to know the number of female medical physicists in the constituent regional federations.

Paper Number: 0278

MEDICAL PHYSICS IN SOUTH AFRICA: A HISTORY AND CURRENT STATUS REPORT

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INTRODUCTION

The use of radiation for cancer treatment in South Africa (SA) apparently started in the 1950's with the application of 226Ra, but records are not available as to who imported these first isotopes. What is clear is that foreign (UK) qualified physicists were being employed at the time and the profession was established around the country.

HISTORY

The first physicists started assisting with the application of isotopes and x-rays in medicine in the mid 1950's. Amongst these was Prof Alan Cormack who carried out the first prototype experiments as a forerunner of Computed Tomography in Cape Town in 1956. In the same year Medical Physics as a profession was first recognised by the then Atomic Energy Board when regulations were published requiring registration of "hospital physicists". It required one year in-service training at a recognized training hospital after the MSc degree in Physics, and two years after a BSc (Hons) degree. SA thus became one of the first countries in the world to regulate the profession.

CURRENT STATUS

Medical Physicists are evenly spread between private and public sector hospitals around SA, predominantly serving the needs of radiotherapy centres, but also active in radiology, calibration laboratories, nuclear medicine and regulation. SA is self-sufficient in education, registration and training, also playing a role in supporting education in the region.

CONCLUSION

Medical Physics is a well-established profession in SA with a proud history stretching back many decades and is growing actively to fill the ever increasing need for skills as technology advances.

Paper Number: 0153

MEDICAL STAFF EYE-LENS DOSIMERTY IN CARDIOLOGICAL INTERVENTION PROCEDURE: EVALUATION OF THE X-RAY ENERGY SPECTRUM.

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Workers involved in interventional cardiology procedures can be exposed to significant scattered radiation field, receiving eye-lens doses that must be evaluated.

This study investigates the X-ray energy spectrum incident to the operator eye and the related dose with and without glasses, during standard biventricular implantation and bioptical control procedure in patient with heart transplanted (both procedures with 2 operators involved). In particular, the relative position between operators heads, glasses and patient isocenter are studied by filming 2 medical team in 5 procedures with 2 cameras operating in a cardiological room equipped with a fluoroscopy C-arm X-ray unit; so the entire procedure – and the scattered field - was simulated using RANDO phantoms to represent patient and operators. The operator eye-dose is evaluated with TL(LiF) dosimeters and the energy distribution of the X-ray scattered field is measured with Amptek (XR-100T) CdTe spectrometer: this give us the directional spectrum over different angular view-position. In particular, with 3D dose maps of patient scattered radiation, it is possible to study the X-ray energy spectrum that impinge on operators, so it is possible to evaluate the correct properties of the different personal protective devices, as eye-glasses.

This study points out the quality of the radiation that interact with the operator eye-lens and the dose contribution on it from the backscattered radiation, evaluated as the ratio between the dose measurements on glass with and without the phantom head.

Paper Number: **0052**

METHODS OF PATIENT DOSE MONITORING IN DIAGNOSTIC RADIOLOGY

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For optimization of medical exposure in diagnostic radiology the monitoring of the patient entrance surface doses (ESDs) should be conducted and compared with established national diagnostic reference levels (DRLs).

The measurements of ESDs in radiography can be carried out by TLD-method. But in Ukraine there are more than 7500 conventional X ray diagnostic units, so the estimation of ESDs on each X ray unit using the TLD method is not possible.

The aim of this study was the estimation of ESD by direct method -TLD and indirect methods - the results of output measurements or dose area product (DAP) measurements. comparison received data.

The results were demonstrated that there is very good correlation between ESDs which were measured by TLD and settlement values of ESDs by indirect methods.The correlation factor of results was R = 0,92. Thus the difference of measured and settlement values of ESDs did not exceed 25%.

Introduction of an indirect method of estimation ESD from the radiation output measurements allows to estimate ESDs values for the basic radiographic exams and to compare them with values of national DRLs. It gives the chance to carry out the target actions directed on optimization of a medical diagnostic exposure and decrease of collective population doses in Ukraine.

Paper Number: 0053

MODELING THE TIME DEPENDENT BIODISTRIBUTION OF 153SM-MALTOLATE COMPLEX AND 153SM FREE CATION USING COMPARTMENTAL ANALYSIS

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The use of compartmental analysis allows the mathematical separation of tissues and organs to determine the concentration of activity in each fraction of interest. A pharmacokinetic model was developed for free Sm-153 cation and [153Sm]-samarium maltolate in normal rats to analyze the behavior of new complex. Biodistribution studies are expensive and difficult to carry out in humans, but such data can be obtained easily in rodents. We have developed a physiologically based pharmacokinetic model for scaling up activity concentration in each organ versus time. The mathematical model uses physiological parameters including organ volumes, blood flow rates, and vascular permabilities; the compartments (organs) are connected anatomically. This allows the use of scale-up techniques to predict new complex distribution in humans. in each organ.

The variation of pharmaceutical concentration in all organs is described with summation of seven to nine exponential terms and it approximates our experimental data with precision better than 1%.

Paper Number: 0143

MONITORING AND TRACKING OF PATIENT FLUOROSCOPY DOSE IN KING HAMAD UNIVERSITY HOSPITAL

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The purpose of our study was to determine typical radiation doses to adult patients undergoing Fluoroscopic procedures, in King Hamad Hospital in Kingdom of Bahrain. Wide variation in patient dose for the same examination was observed. By thorough examination and constant monitoring of patient dose, variations can be explained and adjustment can be made if necessary. Indirect dose monitoring method was a live monitoring of kerma-area product (KAP). Kerma-area product (KAP) also referred to as Dose-area product (DAP) is a measure of the total radiation emitted from the fluoroscopic system entering the patient. This is monitored by a transmission type air ionization chamber mounted on the face of the x-ray tube collimator, which integrates the dose over the entire image field. The average DAP during a barium swallow, 281.1 (maximum 427.5) dGy.cm2, Gastrograf in Meal, 471 (maximum 819.4) dGy.cm2, Cystogram, 244.6 (maximum 425.8) dGy.cm2, Hysterosalpingography, 80.2 (maximum 150.3) dGy.cm2, Endoscopic retrograde cholangiopancreatography (ERCP), 1398.5 (maximum1468.9) dGy.cm2.The assessment of radiation doses determined using a DAP meter is very useful in patient dose management.

Paper Number: 0218

MONTE CARLO DOSE DISTRIBUTION SIMULATION AND DOSIMETRY PARAMETER CALCULATION OF AN MED3633 103PA SOURCE

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INTRODUCTION

One major factor hindering the accurate calculation of dose distribution in breast brachytherapy is the effect of breast tissue heterogeneity, which is composed of glandular and adipose tissues, as well as the surrounding air in the lungs. This factor was investigated in the treated region for selected brachytherapy seeds. This study presents our dosimetric evaluation of a MED3633 103Pa brachytherapy source by GEANT4 technique.

METHODS

The Geant4 simulation toolkit was used to compute the dose distribution of a MED3633 103Pd source located at the centre of a 30 cm × 30 cm × 30 cm water phantom cube. The percentage depth dose (PDD) along the transverse axis of the source was calculated, allowing the isodose curves for 100%, 50% and 25% PDD to be computed. Recommended dosimetry parameters by TG-43 protocol such as the anisotropy function were also calculated for comparison purposes.

RESULTS

The results show that our method could calculate dose deposition in high gradient regions, near the source, accurately. In general, the isodose curves obtained were in good agreement with previous published results. Also, the anisotropy function values compare well with earlier published data (within 5% uncertainty difference) and seem more physically realistic than some previous data.

CONCLUSION

The level of accuracy of the obtained results should be adequate for clinical calculations in the treated region.

Paper Number: 0374

MRI BASED PATIENT-SPECIFIC COMPUTER MODELS OF VERTEBRAE, LIGAMENT AND SOFT TISSUE WITH VARIOUS DENSITY FOR EPIDURAL NEEDLE INSERTION SIMULATION.

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Epidural simulations previously used layers of synthetic silicate materials to represent tissues. Graphical modelling has enabled visual representation of vertebrae and tissues. The accuracy with which previous simulators modelled the physical properties of tissue layer deformation, density distributions and reaction force during needle insertion has been lacking. Anatomical models are generally static, not considering individual differences between patients especially in obese. Our developed epidural simulator aimed to solve these issues. MRI scans of patients were taken after receiving epidural. The MRI and pressure measurement data was used to reconstruct a density model of the tissues, ligament and vertebrae taking into account the internal structure revealed by MRI intensities. Models were generated from MRI matching individual patients with tissue density varying throughout layers, matching the in vivo tissue. When patient MRI is not available a neural network is alternatively used to estimate the patient's ligament thicknesses with over 92% accuracy. A haptic device is incorporated with the graphics tissue model allowing anaesthetists to practice inserting a needle into the simulated epidural space. Changes in pressure, force and resistance to insertion can be felt as the needle pierces each layer of fat and ligament. The main problem with learning to perform epidural is the inability to see the needle location beneath the skin. MRI reveals the internal tissue structure so that anaesthetists can practice insertions on patient-specific models, visualising epidural space distance and needle obstructions. The developed simulator provides a realistic platform to practice and reduces risks of problems during in-vivo procedures.

Paper Number: 0296

NEAR TO REAL-TIME LASER SPECKLE CONTRAST ANALYSIS BASED ON MULTIPLE EXPOSURE TIMES

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The laser speckle contrast analysis (LASCA) was introduced in 1981 by Fercher and Briers for the examination of the perfusion of living tissues. Since the introduction of the method, several enhancements were applied to it. As a result, it allows one to create the perfusion map of the examined cerebral or ocular tissue with high speed and relatively good accuracy.

However, in the case of skin perfusion measurements, the intensive scattering from the non-moving parts of the skin leads to the detrimental decrease of the reliability and accuracy of the obtained results. As a solution for the problem the application of a wide range of exposure times was suggested. Though the implementation of multiple exposure times remarkably enhanced the accuracy (with respect to a conventional laser Doppler system), however, the temporal resolution was decreased significantly.

We present a method which utilizes the LASCA based on multiple exposure times, a novel technique for the proper control of the light intensity, and a unique sampling technique to achieve near to real-time measurement of the skin perfusion. The system based on our method is able to automatically handle the destructive effect of the skin surface and re-tune itself according to the changes of the sample, while it provides full-field perfusion maps with high accuracy, without the need of any precalibrations.

Our method can be an extremely useful tool during the application of post occlusive reactive hyperaemia (PORH) for the examination of diabetic dermadromes, transplantations, as well as cancerous mutations of the skin.

Paper Number: 0150

NEUTRON PRODUCTION FROM PATIENTS DURING HADRON THERAPY AND THEIR RADIATION DOSES: CONCEPT OF "COMPROMISE OPTIMUM INCIDENT ENERGY"

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We were the first to calculate and measure unambiguously the neutron produced from patients during therapy with Bremsstrahlung, and estimated their radiation doses[1] . We were again the first to show that the number of these neutrons is a lot higher with hadrons [2].. There is no reliable/ useful data on this subject. Using the experimental neutron production data from different body elements, we have estimated the fluence and energies of these neutrons from tissue, at the production site, under irradiation with different hadrons. Our results indicate that at least 4.2 neutrons , with energies greater than 5 MeV, are produced for every C-ion of 400 MeV/u energy incident on tissue. This number reduces to 3, 1.4 and 0.3 respectively at C-energies of 300, 200 and 100 MeV /u. For protons these numbers are estimated to be 0.05, 0.2 and 0.4 per proton of energies 100, 200 and 300 MeV respectively. There would be even more neutrons with energies lesser than 5 MeV. The doses to some organs have been estimated, which are not negligible. A "Compromise optimum energy" concept is suggested. But extreme caution is highly recommend before treating patients with hadrons, especially children and younger people who still have many years to live.

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Paper Number: 0399

NEW METHOD TO GET DETECTOR RESPONSE FUNCTIONS FOR PHOTON BEAMS

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Radiation treatment planning system need beam data to calculation dose distributions in the patients. The beam data are measured with small ion chamber. Due to the volume of the detector, the penumbra of dose profile is measured larger than the penumbra of the real dose profile. One can assess the influence of the volume effect of the detector using the response function of the detector. In this paper we present a new method to get response functions of detectors used for photon beams. Two measurements of dose profiles with different source-to-surface-distances (SSD) were used to get a detector response function. The mathematical relation between the two profiles and the detector response function was derived using inverse-square-law and convolution equations. The response function of the detector can be determined using the relation and measured two profiles. To demonstrate the method we measured dose profiles at SSD=100 cm and 120 cm with CC13 (IBA dosimetry, Germany) ion chamber using 3D water phantom, Blue phantom (IBA dosimetry, Germany). Field size was 6x6 cm2 and the depth was 5 cm. The response function of the CC13 was assumed to be Gaussian function. The FWHM of the response function was 6.315 mm. The penumbra of the profile measured at SSD=100 cm was 5.7 mm. The penumbra of the real profile at SSD=100 cm, which can be obtained using the response function and the measured profile by deconvolution, was 2.5 mm. The penumbra of the same profile using Edge detector (Standard Imaging, USA) was 2.9 mm.

Paper Number: 0116

NOVEL PHOTOPLETHYSMOGRAPHY ASSESSMENT OF ORTHOSTATIC INTOLERANCE IN PATIENTS WITH CHRONIC FATIGUE SYNDROME

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INTRODUCTION

Chronic fatigue syndrome (CFS) is a debilitating condition which leads to increased morbidity and significant impairment of quality of life. However, its diagnosis is hindered by the lack of suitable diagnostic tools. Several studies suggested autonomic dysfunction and orthostatic intolerance as common signs.

AIM

This pilot study proposes to use non-invasive photoplethysmography (PPG) technology to assess cardiovascular responses to standing and their clinical value.

METHODS

Study cohorts consisted of 14 CFS patients (Fukuda diagnostic criteria) and 14 healthy control subjects. PPG pulses were collected from the tissue pads of the right and left ear lobes, index fingers, and great toes for 15 minutes, including 10 min baseline (subject supine) followed by 3 min of 70° head-up tilt. PPG signals were sampled at 2 kHz and stored to a computer for subsequent off-line computation of percentage changes in pulse timing (pulse transit time, PTT) and amplitude (AMP) at each body site.

RESULTS

The combined ear, finger, and toe change to standing in PTT was significantly reduced in the CFS group (median 26% against 37%, p=0.002). The change in AMP was not significantly different between groups. Experimental cluster analysis combining timing and amplitude measures provided an overall diagnostic accuracy of 82%.

CONCLUSION

Novel photoplethysmography assessment with cluster analysis has confirmed orthostasis intolerance in CFS and this could become a useful bedside biomarker.

REFERENCE

Allen J., Murray A., Di Maria C., Newton J. L., Chronic fatigue syndrome and impaired peripheral pulse characteristics on orthostasis-a new potential biomarker. Physiological Measurement 2012;33:231-241 doi:10.1088/0967-3334/33/2/231

Paper Number: 0152

NUCLEAR PHYSICS AND ICP-MS-LA (INDUCTIVELY-COUPLED-PLASMA-MASS-SPECTROMETRY WITH LASER ABLATION)) METHODS FOR THE STUDY OF TRACE ELEMENTS IN BIOMEDICAL HARD TISSUES: BONES, TEETH AND KIDNEY/BLADDER STONES

Anwar Chaudhri[1], Nasir Chaudhri[2], John Watling[3]

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As most of us would be aware that to determine trace element concentrations in hard tissues (bones, teeth and kidney/bladder stones) with normal chemical techniques, in not easy and contamination free We have, therefore, developed various nuclear and atomic activation techniques and applied these to determine the elemental composition of calcified tissues (teeth and bones). Fluorine was determined by prompt- gamma- activation- analysis through the reaction 19F(p,α gamma)16O. Carbon was measured by activation analysis with He-3 ions, and the technique of Proton-Induced X-¬ray Emission (PIXE) was applied to simultaneously determine Ca, P, and trace elements in well-documented teeth. Dental hard tissues: enamel, dentine, Furthermore, using a Proton Microprobe, we measured the surface distribution of F and other elements on and around carious lesions on the enamel. The depth profiles of F, and other elements, were also measured right up to the amelodentin junction. We have used the same trechnique to measure the F-contents of experimental animals- on fluoridated water supply and the controls. Furthermore, our results on the micro- distributions of various elements in kidney/ladder stones, using the powerful technique of Laser-Ablation Inductively-Coupled Plasma Mass Spectrometry (La-ICP-MS) are also presented.

Paper Number: 0254

OPTIMISATION OF MYOCARDIAL PERFUSION SPECT/CT IMAGING TECHNIQUES FOR PATIENTS WITH VARYING CHEST WALL ATTENUATION

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The rise in obesity levels over the last decade has brought with it a number of imaging challenges in nuclear medicine. For obese patients, increased noise and scatter, caused by greater soft tissue attenuation, results in substandard image quality. In particular, cardiac perfusion studies using SPECT/CT suffer as a result of this challenge. The aim of this work was to establish optimal image acquisition and reconstruction parameters for obese patients acquired on a Siemens Symbia T2 SPECT/CT.

To this end a myocardial perfusion test object was constructed and incorporated into an elliptical chest phantom capable of simulating a range of chest wall thicknesses. Objective contrast-to-noise and full-width-half-maximum measurements for a series of phantom arrangements, and of varying acquisition parameters, were analysed to establish those parameters producing the best image quality. Similarly, optimal reconstruction parameters were deduced from acquired raw phantom data reconstructed using ordered-subset expectation-maximisation (OSEM) reconstruction and FLASH 3D algorithms.

Furthermore, images of patients with increased chest wall thicknesses, having undergone a range of reconstructions, respectively, were subjectively scored for their diagnostic image quality by radiology and nuclear cardiology clinicians. Using the results of this blind study it was possible to deduce optimum acquisition and reconstruction methods for patients depending on their chest wall thickness, and to correlate these with phantom simulations.

Paper Number: 0093

OPTIMISED IMRT & VMAT PATIENT-SPECIFIC QC USING COMPASS 3D TREATMENT VERIFICATION AND PATIENT DOSE ANALYSIS SYSTEM

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PURPOSE

The demands of patient-specific QC must not limit the application of IMRT and VMAT. We report on commissioning and use of Compass (IBA-Dosimetry), newly introduced in the UK, for IMRT/VMAT. Compass is used for independent 3D dose calculation, with periodic linac measurements, reducing QC time significantly.

METHOD

Commissioning was carried in three parts: (1) creating a beam model using linac physical parameters and measured data, (2) verification of the model's dose calculation accuracy, together with the software tools, and (3) putting the system into clinical use highlighting its capabilities, limitations and any uncertainties in its functionalities and dose calculations.

Six patients' Pinnacle TPS RT plans, structures, and dose, together with CT images, were exported to Compass, with and without supplementary Compass detector measurement. The doses were recalculated and reconstructed on the patient CTs, and compared to the TPS calculation. Protocol analysis of the RT-structures' dose differences and gamma comparisons were performed and reported.

RESULTS

The dose calculation verification of the Compass model was within the TG53 acceptable criteria for a variety of beam geometries and field arrangements. Major limitations of the system, such as DICOM SCP instability and inability to calculate bolus plans were reported to IBA.

Point dose differences were within 2% and gamma passing rates at 2% 2mm criteria exceeded 95% between Pinnacle and Compass.

CONCLUSION

We have used Compass to implement an efficient patient-specific QC method using either conventional linac measurement or as an independent dose calculation algorithm and its limitations were identified.

Paper number 0035

OPTIMISING THE OCCLUSION DOSE MONITOR FOR LONG-TERM RECORDING

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Amblyopia or 'lazy eye' is one of the most common childhood disorders. It is treated using glasses to correct refractive error and by patching the stronger eye to encourage the brain to use signals from the weaker eye. It is important to know how well the patient has complied with their patching and glasses wearing regime when judging the efficacy of the treatment. Occlusion Dose Monitors (ODMs) help to monitor compliance objectively.

We present an optimised ODM paying particular attention to size and battery longevity. Previous ODMs had short battery lives requiring weekly deliveries of monitoring devices to patients (Fronius M., et al 2006). Our ODM uses a Microchip PIC24 16-bit microcontroller designed for extremely low power consumption. This extends the life of a single ODM to over 6 weeks, the typical time between children's Opthalmology appointments. This provides scope to use these devices in large multi-centre trials without modifying the routine patient protocol.

These occlusion dose monitors measure just 27mm x 11mm x 4.5mm and weigh 1.4g which enables them to sit comfortably behind the occlusion patch or on the side of the patient's glasses. This is similar in size to the '2001-type' ODM device developed in Academic Medical Centre, Amsterdam (Chopovska Y., et al 2005) making our ODM one of the smallest available. Data from our prototype design suggests improved reliability compared to the Dutch device with 11% failure rate within one week as opposed to 26% (Fronius M., et al 2009).

Paper Number: 0299

OPTIMISING THE USE OF COMPUTED RADIOGRAPHY IN EXTREMITY IMAGING

Ana Luiza Menegatti Pavan, Diana Rodrigues de Pina, Allan Fattori Alves, Alexandre França Velo, Sergio Marrone Ribeiro, José Ricardo Arruda Miranda

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The objective of this study was to analyze image quality and dose of extremity (hand) examinations in patients using computed radiography (CR), often obtained with a wide range of doses, suggesting the need of protocols for optimal image quality. A computational algorithm was developed in Matlab to discern soft and bone tissue of a computational tomography exam. The thicknesses of tissues were used to build a homogeneous extremity phantom. Phantom was constructed using materials designed to mimic human tissue at diagnostic photon energies: 19 mm of soft tissue-equivalent substitute (Lucite) and 0,8 mm of bone tissue-equivalent substitute (Aluminum). This phantom was used to calibrate the x ray beam. Images of an anthropomorphic hand phantom were obtained using the calibrated techniques and were evaluated by radiologists. Each image was scored using visual grading analysis criteria, selecting the image that provided necessary information for a safe medical diagnosis. This selection was associated with ALARA, to determine the image which would provide the lowest dose to the patient. The selected technique provides a better quality, lower patient dose (reduction of 53,35%), and reduction in x-ray tube charge (reduction of 37,78%) when compared with the clinical routine. Therefore, the implemented calibrated technique has potential to dose reduction in a routine service without loss of medical information in extremity (hand) x ray exams.

Paper number **0030**

OPTIMIZATION OF MEDICAL RADIATION PROTECTION IN SELECTED COMPUTED TOMOGRAPHY (CT) EXAMINATIONS IN SOUTHERN NIGERIA

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Radiation doses received from a CT scan depends on scanner design, examination protocol, operation conditions and operator's technical know-how. Nigeria, in the past five years, has been witnessing an increase in the number of advanced CT facilities such as spiral CT and multi-slice CT which potentially result in higher radiation risk to the patient. Nigeria is currently plagued with; lack of update training of the professionals involved in CT practices, non-implementation of quality assurance programs, non-evaluation of CT scanning parameters for dose reduction, lack of CT database/archives. A few related works (including the IAEA sponsored Regional Project RAF/9/033) have been published by Nigerian researchers, but none of them included findings from CT examinations. This study aims at; reducing the rate of radiation risk to patients undergoing CT examinations, introducing nationwide common protocols for determining CT patient doses and establishing DRLs for most frequent CT examinations. This study entails: survey of CT practises using questionnaire; dose descriptors measurement using a pre-calibrated pencil-type ionization and a digital exposure meter; dose assessments using the ImPACT group protocols; dose reference levels estimation using the third quartile values of dose descriptors; data processing using SigmaPlot and image acquisition using the facility's typical examination protocols. This pioneer study will: proffer a comprehensive survey of CT practices; establish appropriate methods of evaluating medical CT doses; establish scanning protocols and parameters specific to different patient sizes and ages and introduce an ideal Dose Reference Levels (DRLs) for common CT examinations in Nigeria.

Paper Number: 0123

P { MARGIN-BOTTOM: 0.21CM; } P { MARGIN-BOTTOM: 0.21CM; } THE APPLICATION OF RADIATION AND PARTICLE BEAMS FROM A LASER PLASMA ACCELERATOR TO ONCOLOGY

Anna Subiel[1], Silvia Cippicia[1], Gregor Welsh[1], David Reboredo Gil[1], Annette Sorensen$_2$, Colleen DesRosiers[3], Vadim Moskvin[3], Enrico Brunetti[1], Phil Evans[6], Mike Partridge[7], Bjoern Seitz[5], Riju Issac[1], Marc Mendonca[3], Mark Wiggins[1], David Clark[1], Tom McCanny[1], Marek Maryanski[4], Marie Boyd[2], Dino Jaroszynski[1]

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X-rays with energies of a few MeV are the most common form of ionizing radiation used for cancer radiotherapy because they are produced by flexible, compact and affordable machines. As an alternative to X-rays, electron beams are a potential modality. However, the size and costs of conventional electron accelerators restrict their wide use. Thanks to recent and substantive improvements in laser-plasma wakefield accelerator technology, high quality electron beams, with considerably higher energies than conventional hospital LINACs, can be produced in millimetre scale accelerators at a significantly reduced cost. Monte Carlo simulations, dosimetric measurements and preliminary radiobiological results show that the laser plasma wakefield accelerator has potential to become another modality in radiotherapy.

Paper Number: 0250

PARTNER - A UK AFRICA PARTNERSHIP FOR RADIOTHERAPY

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Cancer incidence in sub-Saharan Africa is expected to increase by 150% by 2020 (Globocom). 40% of all cancer cures result from the use of Radiotherapy (WHO), but Africa's personnel and equipment resources for radiotherapy are severely inadequate to meet current capacity needs and future demands. In response to this we have formed a health partnership between UK and Ghanaian Radiotherapy professionals called paRTner to train personnel, implement Quality Assurance and preventive maintenance programmes and to prepare for the arrival of Ghana's first public linear accelerator. This programme will serve as a model for training other centres in the region. In Ghana there are currently two Cobalt-60 units to serve a population of 26 million (in the UK this population would be served by over 100 treatment units), and there are no personnel trained to use and maintain linacs. paRTner is working within the Medical Equipment Partnerships Programme of THET (a specialist global health organisation that educates, trains and supports health workers through global partnerships) to reduce equipment downtime (currently about 30%, with a target reduction to 5%) and improve treatment quality. We are also contributing a case study to THET's good practice guidelines for equipment donation; it's estimated that up to 80% of the medical equipment in some sub-Saharan African countries is donated equipment; the majority of which is unusable. This paper presents the value of the health partnerships model, the implementation of the training programme and also the benefits to UK Medical Physicists of becoming involved in global health.

Paper Number: 0192

PATIENT-SPECIFIC DOSIMETRY CALCULATIONS IN MOLECULAR RADIOTHERAPY

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AIM

Most radionuclide administration methods in molecular radiotherapy are based upon empirical and clinical experience, where the prescribed activity is adjusted by body weight and surface area. This has resulted in the majority of treatments performed with neither prospective, nor retrospective dosimetry. The aim of this work is to develop patient-specific dosimetry methods using Monte Carlo (MC) calculations, as are routinely employed in external beam radiotherapy. Two therapies were considered: intracavitary irradiation of cystic brain tumours with 32P radiocolloid, and pain palliation of bone metastases from prostate cancer with 186Re-HEDP; with 3 and 28 patients studied respectively.

METHODS

An in-house programme developed using the EGSnrc general purpose MC system was used to produce voxel S-value kernels. Voxelised cumulated activity distributions were obtained from co-registered and quantified sequential SPECT scans of the patients. These were convolved with the corresponding kernel to obtain 3D absorbed dose distributions. Cumulative dose-volume histograms of organs/lesions of interest were also calculated.

RESULTS

Results from the cystic brain tumours study show that the absorbed dose delivered by 32P is more accurately predicted from image-based convolution dosimetry than from the routinely used simple sphere model method. Preliminary results from the bone pain palliation with 186Re-HEDP study show large absorbed dose intra- and inter-patient variability, thought to be caused by the challenging image quantification of the small sized lesions.

CONCLUSION

This study showed the importance and feasibility of incorporating patient-specific 3D voxel MC dosimetry methods into clinical protocols, with potential to benefit treatment planning and improve patient outcome.

Paper Number: 0309

PERFORMANCE CHARACTERISTICS OF THE ALBIRA TRI-MODAL PRE-CLINICAL SCANNER

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The Albira Tri-Modal scanner has been installed with the aim of obtaining quantitative data in pre-clinical studies. It consists of the following components: (i) PET with (50 x 50 x 10 mm3) LYSO crystals (with depth-of-interaction capability) arranged in 3 rings giving axial and transverse FOVs of 148 mm and 80 mm, (ii) SPECT with opposing (100 x 100 x 4 mm3) CsI crystals with selectable transverse FOVs (25-120 mm), (iii) X-ray CT delivering 35-45 kVp at a current of 200-400 mA with FOV 70 mm transaxial x 70 mm axial. Spatial resolution, sensitivity and image uniformity have been investigated. At the FOV centre, spatial resolution for PET (using a 22Na point source with diam < 0.3 mm) reaches a plateau of 1.5 mm (MLEM, 12 iterations) and for SPECT (micro-hot-rod phantom) 0.7 mm (OSEM, 2 iterations). Point source sensitivity at the centre of the FOV for PET is 6% and for SPECT 0.02% (pinhole collimation). Using a uniform cylinder spanning the axial FOV, the C.V. of ROI counts axially for both PET and SPECT was 3-5% for repeated scans. For a 30 min PET scan with 5 MBq (160 M counts), the mean ROI voxel C.V. per plane was about 5% (MLEM, 12 iterations). For SPECT with 37 MBq (0.6 M counts) the C.V. was about 22% (OSEM, 2 iterations). CT resolution (measured with a 50 mm gold wire) is about 90 mm. The resolution and sensitivity of the Albira compare favourably with other pre-clinical devices.

Paper Number: **0171**

PERFORMANCE EVALUATION OF THE PHILIPS O-MAR CT METAL ARTEFACT REDUCTION ALGORITHM

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For prostate cancer patients with bilateral hip replacement, radiotherapy treatment planning can be problematic due to metal artefacts in the CT scan. Philips has developed the O-MAR algorithm to address this problem, but it has limitations when multiple metal implants are present.

Scans of an electron density phantom, a water-filled NEMA body phantom, and a hips phantom (both in-air and in the NEMA phantom) were performed on a Philips Brilliance wide-bore CT scanner with and without O-MAR. The evaluation focused on the noise level, beam hardening compensation, and algorithm-dependent artefacts.

Analysis of the electron density phantom evaluated the noise reduction and beam hardening compensation. The in-air scan of the hips phantom demonstrated which errors were reduced, as well as produced, by O-MAR. The comparison between the NEMA water phantom with and without metal implants categorised the reconstruction into reliable regions and affected regions.

The algorithm could reduce the noise caused by metal implants to a certain level with a potential of further reduction. Whilst compensating for beam hardening effects, the software produced other errors small in comparison with those it eliminated. Most regions of the reconstruction of the NEMA water phantom were reliable except for a band-shaped area containing the implants, which was caused both by beam hardening and the reconstruction method. The results of quantitative analysis of the errors can be useful for beam hardening compensation in practical applications, with higher kV reducing the errors.

Paper Number: 0365

PERFORMANCE OF AUTOMATIC IMAGE REGISTRATION FOR TWO DIFFERENT CBCT SYSTEMS; VARIATION WITH IMAGING DOSE

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The performance of automatic image registration algorithms was tested on image sets collected on two commercial CBCT systems and the relationship of performance with imaging dose investigated.

CBCT images of a CIRS Virtually Human Male Pelvis phantom (VHMP) were collected on Varian TrueBeam/OBI and Elekta Synergy/XVI linear accelerators, across a range of mAs settings. Each CBCT image was registered 100 times, with random initial offsets introduced. Image registration was performed using the grey value correlation ratio algorithm in the Elekta XVI software, to a mask of the prostate volume with 5 mm expansion. Residual registration errors were calculated by correcting for the initial phantom set-up error (the median registration error).

Registration performance with the OBI images was similar to that of XVI with residual translations <0.5mm (1s). OBI residual rotations were typically 1.2° (1s) compared to 0.8° for XVI. There was a clear dependence on imaging dose for the XVI images with residual errors increasing below 4mGy. It was not possible to acquire doses lower than ~5mGy with the OBI system and no evidence of reduced performance was observed at this dose. Registration failures (maximum target registration error > 3.6 mm on the surface of a 30mm sphere) occurred in 5% to 9% of registrations except for the low dose XVI scan (31%).

The uncertainty in automatic image registration with both OBI and XVI images was found to be adequate for clinical use within a normal range of acquisition settings.

Paper Number: 0103

PLANNER DOSE PROFILE MEASUREMENT IN NOVALIS -TX - CBCT AND TOMO THERAPY- MVCT IMAGING SYSTEM USING PTW 2D ARRAY .

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AIM

To measure the planner image dose profile of CBCT and MV CT in Novalis- Tx and helical Tomotherapy using PTW 2D array and the dose profile were compared with different image protocol .

METHODS

Novalis-Tx OBI system and Tomo therapy machine have some preloaded imaging protocol for IGRT . In MVCT having three different image protocol with different fan beam field width of Fine , Normal and Coarse . in the same way OBI CBCT machine have separate arm of Kv image with amorphous silicon imaging panel have a set of protocol with appropriate image contrasted parameters as it follows.1) Standard-Dose Head 2)Low-Dose Head 3) High-Quality Head 4) Pelvis 5) Pelvis spot light 6) Low-dose thorax. The planner dose profile in CBCT and MVCT the Octavius phantom was used with 2D PTW array connected to the Verisoft . The phantom and 2d array was scanned for different protocol at the same time the planner dose profile were measured for different image protocols for both machine . This normalised planner dose profiles were compared with other imaging protocols as well with MVCT.

RESULTS AND CONCLUSION

The dose profile pattern measured using PTW Array of CBCT image profile compared with MVCT image profile and we found that in the MVCT planer profile ,the variation along the axial direction is 11% higher whereas in CBCT the percent variation is more than 80% with respect to the central array .

Paper Number: 0028

POST MORTEM ANALYSIS OF SEED PLACEMENT IN PROSTATE BRACHYTHERAPY (TWO CASE STUDIES)

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INTRODUCTION

Two patients who had undergone prostate brachytherapy died unexpectedly from unrelated causes. Their families requested that their bodies should be cremated. Due to the residual activity the prostates had to be harvested from the bodies. This afforded us the ideal opportunity to physically verify the seed placement.

MATERIALS AND METHODS

The prostates were implanted with I125 seeds. In one case, due to a previous hip replacement, the implant and post plan were challenging. The prostates, along with the adjacent sections of bladder and rectum were removed during the post mortems. The prostates were scanned again, new post-op plans generated from these CT's and the prostates dissected using 5mm thick transaxial slices in analogy to the US study. The intra-op and two post-op plans could then be compared and augmented by the information obtained by the dissection.

RESULTS

There was a good correlation between the three plans for both patients. In both cases all the seeds bar one were recovered. It was determined that the missing seed must have been lost through the urethra in both cases.

CONCLUSION

The dynamic feedback implant technique used by our group gives good results. The intra-op dose distribution is a good predictor of the actual dose delivered. Due to the shape of the urethra one should never use a needle placed directly under it as a seed can be deposited unknowingly in the urethra and thus expelled.

Paper number: 0010

PRECISION COMPARISON OF DIFFERENT DOSE CALCULATION ALGORITHMS USING AN IN-HOUSE DESIGNED PHANTOM

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A phantom for use in radiotherapy treatment planning of human pelvic anatomical region has been designed with six hollows for inserting materials mimicking different biological tissues and the ionization chamber. The yellow plaster of Paris was used to mimic the bone, Styrofoam for the lung and water for soft tissue. The phantom was scanned with Toshiba-Asteion CT-scanner and the images were transferred to the CMS-XiO Treatment Planning System with 3 different algorithms. Measurements of Monitor Units were conducted using 6 MeV photon beams from the ELEKTA-Precise clinical linear accelerator with iso-centric set up. The test of the phantom was done using Fast Superposition (FSS), the Superposition (S) and the Convolution (C) algorithms. Results with FSS algorithm showed better accuracy than S and C. The standard deviation of measurements with bone heterogeneity for all plans varied between +2% and -3%. FSS has faster computation speed than other algorithms; however C has a good balance of speed versus precision in homogeneous medium. Choice of algorithm for use should not be based on the speed of computation alone but also on the accuracy, especially for applications with modern radiotherapy techniques such as intensity modulated radiation therapy (IMRT).

Paper number **0043**

PRELIMINARY CLINICAL EXPERIENCE WITH IN-HOUSE LOW COST AUTOMATIC CANCER PATIENT MOVEMENT MONITOR FOR RADIATION TREATMENT USING A MICRO SWITCH CONTROLLED CIRCUIT

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INTRODUCTION

The main aim of the present investigation was to fabricate indigenously micro-switch controlled circuit based automatic patient's movement monitoring device(APMMD) that immediately halts teletherapy treatment if a patient moves claiming accurate field treatment. This device prevents unnecessary radiation exposure to a patient's normal tissue in situations where immobilization devices are not utilized.

MATERIALS AND METHODS

The APMMD consists of two micro switches, two LED's, two buzzers and two AA batteries. These devices were fixed in the Radiotherapy machine couch by using magnets and screws. The two sensor devices were placed over the treatment table on both ends of the lateral sides. Patients were placed in between the two sensor device which is near the treatment area. The movable rod of the sensor should place near the treatment site of the patient and the rod should touch the patient's body on both sides. If the patient moves left lateral side, the left inner rod moves inward to the outer rod, and the micro switch is activated, so that the alarm is activated and the LED goes to OFF position automatically. Furthermore, the radiation get stops automatically.

RESULT

The APMMD is used with the radiotherapy machine. This equipment is utilized for observing the movement of 109 patients with different types of cancer. Our preliminary clinical results indicate that 78 patients were moved from their position during the treatment, whereas the rest received the radiation without movements. The device and alarm system can detect patient movements with a sensitivity of about 0.5cm.

Paper Number: 0239

PRETHERAPEUTIC DOSIMETRIC STUDIES AND POSTTHERAPEUTIC DOSIMETRIC VERIFICATION IN NUCLEAR MEDICINE THERAPEUTIC APPLICATIONS

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INTRODUCTION

This paper presents our experience in clinical dosimetry for the 131I thyroid treatments and the 90Y 177Lu Radiopeptide therapy

In the 131I thyroid treatments, the PreTherapeutic dosimetry has the purpose of identifying the optimal activity to be administered to the target in a single solution and in the metastases to evaluate the dose to red marrow

In the Radiopeptide therapy timed in 6-8 cycles, after the first and last cycle PostTherapeutic dosimetric verification is performed;

MATERIALS AN METHODS

For the quantification of the residence time:

Calibration of curiemeter
Check on the image quantification of planar, SPECT-CT and PET-CT with on phantom reference
Studies on a phantom of the best method of correction of : attenuation , scatter, PVE and best method of segmentation of the targets
Series of imaghes are repeated to study the parameters of the exponential kinetic models
For the quantification of the masses
Execution of hybrid SPECT-CT/PET-CT examinations or ultrasound techniques
For evaluation of factors S
Use the factors S Olinda with the correction for the actual mass
For the evaluation of the dose in not uniformity uptake is applied voxel dosimetry with simplified method (MIRD17)

CONCLUSIONS

The error associated with the absolute quantification for the radioisotopes gamma emitter and for 90Y (with Bremsstrahlung SPECT - CT or low sensitivity PET) is within about 20%

Verification of the heterogeneous activity distributions in the tissues is affected by the low uniformity tomographic and detect the non-uniformity only if more than 30% in SPECT

Paper Number: **0065**

PRE-TREATMENT VERIFICATION OF INTENSITY-MODULATED RADIATION THERAPY IN PAEDIATRIC PATIENTS: ADEQUATE ESTIMATION FOR TOLERANCE LIMITS

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This work was aim to establish adequate tolerance limits based on a certain defined institutional indices and generate published data presenting our results to the radiotherapy community. One hundred paediatric patients were treated using 6-MV X-ray beams produced by Siemens ONCOR Expression linear accelerator. The clinical step-and-shoot IMRT treatment plans were designed using KonRad release 2.2.23. For two treatment sites (abdomen, head and neck), the fluence maps generated by the treatment planning system were all delivered for the quality assurance which included absolute dose verification for all treatment fields, relative dose verification for each treatment field. The 724 fluence maps were analyzed at three different criteria using the gamma index tool. The 3% dose difference of local prescribed dose /3 mm was considered adequate. The passing rate for all fields of all plans always exceeded 70%. The dose differences between the measured and calculated doses ranged from -2.2% to +4% [mean and standard deviation (s): 1.4 ± 1.5] for the abdominal case, and from -3.3% to +5.6% (1.3 ± 1.6) for head and neck case with total confidence limit 0.046 (4.6%). The 14/100 (14%) of the absolute point dose measurements were out of ±3% from the dose predicted by the treatment planning system. Only two cases were below -3%, while 12 cases over +3%. At 3% dose difference of local prescribed dose /3 mm criteria, a 75% passing a gamma criterion and 3% for absolute point dose can be achieved for abdomen and head and neck treatments site.

Paper Number: 0211

PRIMA RESULTS ON PROTON IMAGING

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The PRIMA experiment, funded by INFN Italy, is aimed at developing a proton Computed Tomography prototype based on tracking single protons. It consist in the use of silicon microstrip detectors to measure the position and direction of individual protons before and after they traverse the phantom, and a calorimeter for measuring particle residual energy. A small prototype with a field of view of 5 x 5 cm2 was tested, under 60 MeV and 180 MeV proton beams. In this paper the experiments concerning proton imaging will be presented.

Reconstructed images show the good performances of the device, with spatial resolution fulfilling the stringent requirements of a pCT device and demonstrate the validity of the working principles of pCT in a small scale prototype.

Paper Number: 0008

PRONE OR SUPINE? A SERVICE EVALUATION TO FIND THE OPTIMUM POSITION FOR ANAL CANCER PATIENTS BEING TREATED WITH TOMOTHERAPY.

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Tomotherapy is ideally suited for planning the complex volumes required for anal cancer treatment. Prior to this study anal cancer patients treated on tomotherapy were routinely scanned, planned and treated in the prone position. It was hypothesised that the supine position would provide a more stable patient set-up with the added benefit of matching the orientation used in MRI and PET diagnostic imaging. 5 patients were scanned in the supine position to investigate whether this was practicable.

The initial dose statistics of the plans were examined and adaptive assessments were carried out during the first week of treatment to ensure that the doses delivered were consistent with those planned. If differences were found these assesments were repeated. No significant difference due to patient position was detected between the dose statistics of the prone and supine groups.

During analysis of the data it was observed that bladder filling was variable and had a significant effect on the dose distribution due to altered organ position. As a result of this, a new bladder filling protocol has been adopted for these patients.

Reproducibility of patient position and comfort was found to be better for prone patients. Additionally the treatment radiographers suggested that it was easier to position bolus in the anal cleft when patients were prone. It was therefore concluded that all patients should continue to be scanned in the prone position.

Paper Number: 0340

QA IN CONTEMPORARY INTRACRANIAL RADIOTHERAPY TECHNIQUES: A HOLISTIC METHOD EMPLOYING A MULTITUDE OF 1D, 2D AND 3D DOSIMETERS.

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Dose verification in contemporary radiotherapy techniques constitutes an imperative element of quality assurance programs and largely determines clinical effectiveness. This work presents a pilot implementation of an experimental QA method for intracranial radiotherapy techniques, especially those involving complex 3D dose distributions and narrow radiation fields, where electronic disequilibrium is usually encountered. A specially designed Plexiglas® phantom is presented, simulating a head & neck region. A set of inserts are used to facilitate irradiation with several 1D, 2D and 3D radiation detectors: ionization chambers, TLDs, films and polymer gel.

The whole chain of steps involved in the treatment process is applied on the phantom bearing each dosimeter. A comparison is subsequently performed between the planned and delivered dose-distribution, as the latter is determined by a multitude of detectors. TPS volume calculation accuracy and its impact in volumetric parameters used (e.g. DVH) can also be assessed. In case of MRI based planning it is also possible to evaluate relevant inherent geometric distortions which might heavily affect the clinical outcome, by either using the polymer gel dosimetry option or the several control points machined throughout the phantom's volume. Preliminary results on stereotactic radiosurgery showed that accuracy and precision accomplished in an established or newly introduced radiotherapeutic protocol can be evaluated prior to actual clinical implementation.

Research implemented within framework of Action «Supporting Postdoctoral Researchers» of Operational Program "Education and Lifelong Learning" (Action's Beneficiary: General Secretariat for Research and Technology), co-financed by ESF and the Greek State.

Paper Number: 0282

QDOSE, A TREATMENT PLANNING TOOL FOR INDIVIDUALISED DOSIMETRY-BASED MOLECULAR RADIOTHERAPY

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The implementation of individualised clinical dosimetry routines for the therapeutic administration of radiopharmaceuticals is impeded by the lack of well-defined, robust and fast commercial software systems to support patient-specific treatment planning. As a result, neither prospective nor retrospective dosimetry is performed for the majority of patient treatments.

qDose aims to provide a fast, user-friendly treatment planning system for molecular radiotherapy. It performs voxel-based analysis of activity, cumulated activity and absorbed dose for diagnostic and therapeutic radioisotopes in 2D and 3D based on co-registered images in DICOM or Interfile formats.

The application generates 3D absorbed dose maps for target tissue and surrounding organs, by convolution with a dose-voxel kernel or from the self irradiation voxel S-value.

qDose provides tools for statistical analysis of the results, e.g. time-activity graphs, dose-volume histograms and image statistics, and supports report generation through export of data in XML-based format and absorbed dose map images in the DICOM and Interfile formats.

The application is developed in C++ and C# for MS Windows, and uses the open source image visualisation toolkit VTK.

qDose can be used by both clinical and research scientists and in teaching. It facilitates individualised clinical dosimetry, and can be a valuable tool to develop and implement clinical dosimetry protocols for molecular radiotherapy in the future.

Paper Number: 0359

QUANTIFICATION OF AFFECTED AREAS BY STROKE USING WAVELTS AND FUZZY C-MEANS CLUSTERING

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Chronic noncommunicable diseases (NCDs) such as stroke became predominant nowadays, killing approximately 100,000 people per year in Brazil. It is estimated that in 2015 over 18 million new cases of stroke will be recorded, thus it is considered a leading cause of death in Brazil and in the world. There are two types of stroke, the ischemic and the hemorrhagic. The computed tomography (CT) and the magnetic resonance (MRI) are the techniques used to detect the stroke. MRI has a greater detection of the disease, however it is very expensive and the exam time unfeasible the use of MRI for population mass. Therefore mostly exams are performed using CT, even if the image method has low capacity of detection for ischemic stroke, where presents densities similar to the encephalic mass, hindering its perception on the image. For a good efficacy of the treatment, the detection of the disease has to quickly, because in matter of hours it spreads out through the brain.

Thus the main of this research is to detect this disease through enhancement techniques, as morphological filters of detection and frequencial analysis by Wavelets, as well as Fuzzy c-means clustering to detect clusters on image associated to stroke, using the software Matlab®.

The wavelet filter enhanced the tomographic images, improving the visualization of the affected areas. Fuzzy c-means clusters proved to be very efficiency on detection. It's expected to contribute for a safe medical diagnosis and quantification of affected structures, providing greater clinical information through physical imaging processing.

Paper Number: 0384

QUANTITATIVE EVALUATION OF TUBERCULOSIS ACTIVITY

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Tuberculosis (Tb) is one of oldest disease and still very common in underdeveloped countries. The pathology of Tb is mostly determined by the intense inflammatory process and scarring of the lung. Identify these findings rightly is very important to choose the right conduct for patient and also to evaluate efficiency and sequelae of the treatment used. For this study we evaluated four high resolution tomography computerized (HRTC) for patients who had Tb in activity and two healthy person as control using specific algorithm to quantify the inflammation process, fibrosis, emphysema, and cavitations. Quantifier algorithms were developed to distinguish abnormal regions in a pre-selected lung field (manually), being -920HU(Hounsfield Unit) for emphysema and cavitations and 70HU for fibrosis and inflammation process. The presented algorithm is a breakthrough in lowering the bias of the subjectivity of visual assessment, standardizes the findings objectively and streamlines de clinical research in Tb. Primary evaluations of these HRTC allowed yields that algorithm did not confuse abnormal regions with normal structures in lung. Furthermore, we have found as preliminary results that patients with Tb in activity had around 13,06% of the lung with Inflammation Process or Fibrosis and 16,37% with Emphysema or Cavitations. As future objectives, we aim to set up the differentiation of these onsets, then we will be able to specify the Tb activity, compare the effectiveness of treatments and also draw a quantitative overview of the disease.

Paper Number: 0244

QUANTITATIVE GA-67 SPECT/CT IN NECROTISING OTITIS EXTERNA

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INTRODUCTION

Necrotising Otitis Externa (NOE) is a rare but serious infection of the external ear and skull base. Gallium-67 SPECT/CT imaging is a sensitive measure of the development and progress of the disease. However, there is no consensus in the literature as to the best way to quantify the uptake.

METHOD

Nine patients had baseline scans at a single institution between December 2011 and February 2013. 150 MBq Ga-67 Citrate was injected i.v., with SPECT/CT at 24 hours from injection, and reconstructed using 3D-OSEM incorporating distance-dependent resolution correction, scatter correction using a triple-energy window method, and attenuation correction. Images were quantified using count in the maximum voxel, the mean count in a 15ml VOI around the maximum voxel, and the ratio of max and mean counts in the lesion to the normal side (lesion:normal L:N)..

RESULT

Four studies were assessed as positive for bone infection, three as soft-tissue uptake, and two as negative. Positive studies had max 550 (SD 190), max L:N 3.3(0.5), mean 208(65), mean L:N 2.7(0.5). Soft-tissue studies had max 229(138), max L:N 1.3(0.4), mean 101(51), mean L:N 1.3(0.3). Negative studies had max 160(6), max L:N 1.0(0.0), mean 77(3), mean L:N 1.0(0.2).

CONCLUSION

The max and mean count is higher in positive studies than soft-tissue and abnormal, but there is some overlap with soft-tissue counts. The L:N ratio is higher for positive studies, and clearly distinguishes bone infection from soft-tissue or negative studies.

Paper number **0106**

RADIATION DOSE EVALUATION OF COMPUTED TOMOGRAPHY IN NUCLEAR MEDICINE

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NuclearMedicine is realize SPECT-CT studies, where the CT is used to precise localization of the neoplasias and osseous metastasis lesions that are diagnostic and detected for only gammagraphy studies. Later the acquisition of images is realized one fusion images to compare lesions with anatomic structures. These Images taken to CT doesnot request neither high-spatial, contrast-resolution nor noise, parameters that increase the radiation-dose of patient but what these images arenot medical justification because it not used medical diagnostic if not to get osseous structural image but if to fuse the gammagraphy image with structural image, that this radiation-dose must be as lower possible, but it is careful due to the unique need is the osseous structure in the this projections. To evaluate retrospectively the protocol used to osseous-gammagraphy in the last 5 years. This protocol was be apply to ACR phantom CT and was measure the radiation-dose. Then, we choose the kVp, mAs, pitch and collimation parameters to vary the image quality without careful neither high-spatial, contrast-resolution nor noise. Finally these parameters found were applied in 20 patient and determinate the image quality and the radiationdose. The SPECT-CT studies of Nuclear-Medicine the radiation-protection of patient hasnot been of interest to study due to the patient has administrated one radiopharmaceutical, but the study of CT to the fusion of images that not have medical justifications of one diagnostic. Therefore, the study of protocols optimization to need the nuclear physician influence in the one reduction of radiation-dose of patient around 10% less.

Paper number **0069**

RADIATION PROTECTION STATUS AT RADIATION ONCOLOGY, BPKM CANCER HOSPITAL, NEPAL

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BPKM Cancer Hospital, Chitwan, Nepal

OBJECTIVE

The objective of this work was to evaluate all the safety procedures toward the radiation protection for workers in the radiation oncology department.

MATERIALS AND METHODS

The annul thermoluminescent dosimeters (TLDs) reports for five years of the staffs were evaluated, radiation surveys were done in the control consoles, radiotherapy machines room and waiting areas of all machines using Aloka survey meter.

RESULTS

The five years TLD reports shows that the whole body dose of the individual staffs is found within the annual dose limit except the accidental exposures. Radiation exposures in the working areas are also safe limits.

CONCLUSION

The radiation safety practices for radiation protection are satisfactory and the radiation workers of the departments are found working within safe limit.

KEY WORDS

Radiation protection and safety, ICRP, Dose limits, TLD, radiation devices

Paper Number: **0081**

RADIOACTIVE LABELING OF RHINOCEROS HORNS FOR IDENTIFICATION AND SECURITY PURPOSES.

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Rhinoceroses are being lost at an alarming rate to illegal poaching. Attempts have been made to identify the source of recovered Rhino horn through trace element and genetic analysis. While the rhino horns are micro-chipped, it is very easy for the poachers to find and remove these chips.

In our proposal radioactive tracers will be dispersed throughout the entire horn of the animal. Radiation detectors fitted at ports of exit and entry should be able to pick up the horns hidden in other consignments. The source of the recovered horns could also be established.

This study will be used to select the appropriate combination of radionuclides, to develop effective means of delivery and to evaluate detectability of the horn while ensuring that no harm befalls any animal. Legal aspects are also being addressed.

Initially the technique of tracer delivery will be studied in vitro using 99mTc. A vacuum technique will be used to drawn a resin into the horn, the distribution will then be verified using SPECT. Once the technique has been perfected it will be done on a single test animal to determine how well the procedure is tolerated before a National program is rolled out.

Each radio-labeled horn will be considered as a source and will have to be licensed. While ingesting powdered radio-active Rhino horn will be deleterious to the user our legal advisors have given the green light to the procedure since the danger is a side effect and not the primary reason for the labeling.

Paper Number: 0169

RADIOGRAPHIC AUTOMATIC EXPOSURE CONTROL TESTING WITH TRANSPARENT AND IONISATION CHAMBERS

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INTRODUCTION

A Raysafe Platinum Plus QA kit was purchased to replace the aging ionisation chamber based equipment in a diagnostic radiology physics department in Dundee. A comparison of measurements was made using the old and new equipment with the only significant variation in result found for Automatic Exposure Control testing for Radiographic systems. This work investigates why this difference was found.

METHOD

A series of equivalent exposure tests were designed to investigate the effect of everything listed below to determine the source(s) of the difference;

Chamber;

Response across kV range

Response to scattered radiation

Response to beam quality

Linearity across dynamic range

And;

AEC response to CR cassette cut-out

Results

There were significant differences found in each chamber's sensitivity to scattered radiation, which was generated using Perspex positioned as a patient would be. The respective CR cassette cut-outs also had a different effect on the AEC system.

CONCLUSIONS

The results recorded during routine AEC testing - post exposure mAs and AEC receptor dose - are significantly different between the use of two different chambers and associated CR cassette cut-outs for the same x-ray system. The cause of these differences was identified and a correction factor derived, to be applied whenever it is necessary to compare the results as measured with one set of equipment to that measured with the other.

Paper Number: 0386

RADIOPROTECTION OF INDIVIDUALS OCCUPATIONALLY EXPOSED OF NUCLEAR MEDICINE SERVICE OF HOSPITAL DAS CLÍNICAS DEPERNAMBUCO

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Nuclear Medicine (NM) is the medical specialty which uses radionuclides combined with drugs to produce diagnostics images or to make therapeutic treatments. As any activity involving the use of ionizing radiation NM should follow the three basic standard of radioprotection: justification, optimization and dose limitation. The purpose of this paper is to evaluate the radioprotection system of the Nuclear Medicine Service (NMS) of the Hospital das Clínicas de Pernambuco (HC/PE). The data used in research was the effective doses (E) from 56 individuals occupationally exposed (IOE) in period of nine years (2002-2010). The paper reveals that the NMS is optimized keeping the doses As Low As Reasonably Achievable, showing most of doses by employees is in the interval 0 mSv ≤ E < 1 mSv, exceeding the limit value of dose specified by the Comissão Nacional de Energia Nuclear (CNEN) of E ≥ 20 mSv, only in a case in 2005. The paper still show over the years the quantity of employees increased almost double since 2002 to 2010.

Paper Number: 0166

RECONSTRUCTION ACCURACY OF AN INTRACAVITARY APPLICATOR FOR CERVICAL CANCER BRACHYTHERAPY: COMPARING CT AND X-RAY IMAGING

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The purpose of this study is to check for reconstruction accuracy using CT and digital x-ray based systems. Recently, the image acquisition system has changed from x-ray radiography to CT. Therefore, it is essential to check for the introduction of new imaging modality for applicator reconstruction. For our purpose, three standard tandem applicators with different angles (15°, 30° and 45°) were used to construct a phantom. The applicators were CT scanned and x-ray radiographed. Resulting image sets were manually reconstructed to check for dummy source position and phantom geometry. Results indicate point localization can be done with accuracy < 1 mm. Mean dwell times were 84.42, 78.54 and 73.78 s in CR, and, 83.06, 79.56 and 74.04 s in CT, for 15°, 30° and 45° applicator angles, respectively, with no significant difference. However, dwell time variations were 0.38, 0.57 and 0.68 s in CR, and 2.03, 1.14 and 2.26 s in CT, for 15°, 30° and 45° applicator angles, respectively. CR method had better reconstruction reproducibility for 15°, 30° and 45° applicators in terms of source dwell position and hence dwell times. A variance test for dwell time showed that there is significant difference for 15° and 45° applicators, while there is no significant difference for 30° applicator. The position of dummy source inside the metal applicator was only visible on radiography while in CT it was not visible due to metal artefact. Manually reconstructing metal applicators in CT might be the main reason of such significant differences.

Paper Number: 0379

RENAL FUNCTION EVALUATION BY AC BIOSUSCEPTOMETRY

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The alternative current biosusceptometry (ACB) system is a biomagnetic technique quite used for studies regarding the gastrointestinal tract. The association of an ACB system to magnetic nanostructured particles provides new approaches able to evaluate a whole other class of biological properties. The main objective of this preliminary study was the development of a biomagnetic instrumentation, able to evaluate the renal function of rats associating specific magnetic nanoparticles (MNP) to the ACB system. This technique principle is based on a magnetic flux transformer which the acquired signal is related to the magnetic tracer concentration in the analyzed region. The MNP used was a nanostructured 15 nm diameter ferrite coated with citrate. The magnetically marked solution, was injected in the jugular vein of 10 male Wistar rats. The kidneys was accessed through a small incision in the animals back. Thus, the ACB sensor could be positioned close to the organ. The study consisted in real time monitoring of the MNP injected and its passage through the animal kidneys. The time intervals related to these particles arriving, retention and elimination at the organ represents the renal function. From the obtained data, it can be anticipated that will be possible to constitute a normality pattern for each parameter and its relations, analyze the normal behavior of each organ and process, and also the influence of pathologies and drug administration on the renal function and its specifics process. Also, with some system optimization, will be possible to analyze this processes on a noninvasive way.

Paper Number: 0155

REVIEW OF HDR PROSTATE 'STUCK SOURCE' EMERGENCY PROCEDURES (A WORK IN PROGRESS)

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This report aims to evaluate and test emergency procedures for a high dose-rate source that does not return to its safe (i.e. a 'stuck source') in a number of centres across the UK.

A 5-step risk assessment was used to evaluate the effect of complex prostate applicators (up to 18 needles) on 'stuck source' emergencies. To test the suitability of procedures and treatment software, a ‘stuck source' emergency was simulated. The source was then positioned inside water phantoms to ensure the source could be located with a compensated Geiger-Muller counter. A questionnaire will be sent to UK HDR centres to determine if procedures consider complex applicators.

The simulation showed the most appropriate source retrieval technique was to remove the containing needle and identify that the source is no-longer within the patient, minimising staff and patient exposure whilst maintaining the closed system of the after-loader. Tests showed that a compensated Geiger-Muller counter is suitable for ascertaining if the source is within a patient. Further simulations will be presented to determine whether treatment systems present the source location in a ‘stuck source' scenario.

The results will indicate whether respondents have considered complex applicator ‘stuck source' procedures, and evaluate suggestions.

Centres should ensure the treatment systems indicate source location at all times, and emergency procedures are in-line with the manufacture's and the American Association of Physicists in Medicine's recommendations (TG59). This review of emergency procedures has highlighted inadequacies in the previous methodology and suggested improvements which will protect staff and patients.

Paper Number: 0293

REVIEW STUDY FOR USING MYOCARDIAL PERFUSION SCAN IN DIFFERENT NUCLEAR MEDICINE DEPARTMENTS IN JEDDAH AND COMPARE IT WITH OTHER PROTOCOLS

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Myocardial perfusion scan is a nuclear medicine procedure that illustrates the function of the heart muscle (myocardium). It evaluates many heart conditions from coronary artery disease (CAD) to hypertrophic cardiomyopathy and myocardial wall motion abnormalities.

Because of the difficulty and accuracy of the myocardial perfusion scan there are many clinics and hospitals around the world use different protocols, interpreting and reporting methods to show the results of the examination.

The main purpose of this project is to assist nuclear medicine practitioners in recommending, performing, interpreting, and reporting the results of myocardial perfusion imaging studies related to other procedures such as European Association of Nuclear Medicine (EANM), ICRP, and other association then compare that procedures with some procedures done by some local hospitals in Jeddah. Additionally, comparing the salient features of the available protocols will be studied, where the advantages and disadvantages of each protocol should be examined.

Paper Number 0090

ROLE OF NUCLEAR MEDICINE IN THE SUPPORT OF CANCER MANAGEMENT IN GHANA

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Ghana received its first SPECT system in 2005. With diagnostic accuracy being a target in nuclear medicine imaging, performance evaluation tests were successfully performed on the installed Siemens e.cam® SPECT system at Korle-Bu Teaching Hospital in Ghana according to NEMA protocols. On the basis of satisfactory testing results, the Siemens SPECT system has been applied in number of studies including thyroid, renal and bone scintigraphy. Since installation of the system, bone imaging has accounted for ~ 83% of scintigraphic studies at the Hospital. Female reported cases have dominated over male reported cases, with peak age at bone tumour detection between 51 and 60 years. Diagnosed bone tumours with their origin in the cells of bone itself have been found to be less prevalent relative to metastasize tumours, notably the prostate. Diagnosed metastatic bone tumours due to spread from prostate cancers have contributed to 19% of bone tumour cases reported. With PET's ability to provide images of better resolution and sensitivity than SPECT, the study has been extended to focus on improvement of diagnostic accuracy through development of improved codes for fusion of prostatic images from PET, CT and ultrasound, based on the principle of mutual information. Codes in MATLAB are being developed to improve on image quality, and the images from the PET/CT and US systems co-registered. The research on image fusion would not only be for diagnostic purposes but help in the better assessment of doses and tumour volumes for improved dose calculation algorithms in treatment planning.

Paper Number: **0149**

ROTATIONAL CONTRIBUTION OF PROSTATE MARGINS

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PTV margins are applied to allow for a combination of possible treatment setup and delivery errors and patient or organ movement. The Tomotherapy Hi-Art systems at Addenbrooke's Hospital provides six Degrees of Freedom (DOF) correction data (both translational and rotational) from daily megavoltage CT scanning, but only allows for four DOF (x, y, z and roll) correction; thus pitch and jaw corrections cannot currently be made. The aim of this study is to quantify the margins required for positional errors due to typical prostate rotations.

Using CTV co-ordinates from five prostate only structures, and five prostate and seminal vesicles (SV) structures, rotations of small known angles (≤15º) were applied using MATLAB around the centre of mass of the structure. The margin required to achieve 99% coverage was calculated by comparing the rotated structures with dilated structures grown from the original CTV.

The mean margin required per degree rotation for prostate only was 0.29mm/º, and for prostate and SV was 0.45mm/º. For yaw, pitch, and roll rotations respectively, these results break down to 0.32, 0.34, and 0.21mm/º for prostate only, and 0.45, 0.50, and 0.41mm/º for prostate and SV structures.

A result of using structures drawn on axial CT slices means that there is poor resolution in the sup-inf direction which limits the ProSoma growing algorithm used to 3mm steps. This is seen in the larger margin required for yaw and pitch rotations.

Paper Number: 0241

ROUTINE QUALITY CONTROL OF LINEAR ACCELERATOR JAW POSITION WITH AN ELECTRONIC PORTAL IMAGING DEVICE

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AIMS

The use of electronic portal imaging devices (EPID) for routine quality control (QC) of linear accelerator parameters is well established. The use of EPID for QC is being developed at our institution and we report results of its implementation for routine measurement of radiation/optical coincidence of collimator jaws.

MATERIALS & METHODS

An in-house jig was positioned on the couch at a source-to-surface distance (SSD) of 100cm. Images were acquired using an aS1000 PortalVision™ EPID (VMS, CA) that were analysed using in-house software. Radiographic film (Kodak X-Omat V) was positioned on the couch immediately after EPID acquisition and the coincidence between the radiation and optical fields between the two techniques were compared.

RESULTS

The measured difference between EPID and film was 0.17±0.75mm (95% CL, n=84) for all jaw and energy combinations. Supplementary work indicated that the EPID is able to detect a 50% radiation edge to within 0.02±0.04mm (95% CL) with an end-to-end test indicating the accuracy was ±0.40mm (95% CL). In contrast, the film-based approach involves several manual steps, with a conservative estimate of accuracy being set ±0.75mm. Given the uncertainties associated with film, the agreement is acceptable.

CONCLUSIONS

The EPID method presented here is ideal for routine QC owing to the speed of which images can be acquired and analysed at the treatment console. The EPID is now in routine clinical use at our centre and its use for additional QC such as opposing collimator junctions, picket/garden fence tests and pre-treatment IMRT/VMAT QC is being developed.

Paper Number: 0351

SEMI-AUTOMATED IMAGE-BASED LINAC MECHANICAL QA PROGRAMME

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Periodic checks of linac mechanical parameters form part of any radiotherapy QA programme, and standard tests can be found in guidelines such as the IPEM81. Many of these tests use light field/cross hair as reference and are often subjective.

We implemented image-based computer analysed tests of linac's mechanical parameters. Essential to the system is the use of MLC leaf edges as a primary and in-room lasers as a secondary reference for definition of anatomy planes and directions. All tests are based on radiation field, and analysis is performed using dedicated MATLAB scripts.

The general procedure for each test consists of image acquisition followed by automated analysis. All tests are based on MV or kV images of either a dedicated MLC pattern or a standard Varian iso-cube ball bearing. In addition to all standard mechanical parameters the programme includes tests of MV-kV isocentre coincidence in both 2D and 3D, isocentric error sphere including gantry, collimator & couch rotation, and all degrees of freedom of both MV and kV imagers. Specific method was developed to test collimator rotation independent of beam collimation device.

The programme has been in use one year on two Varian linacs. Image acquisition (linac) time is 2 hours. Following semi-automated analysis takes extra 15min. Compared to traditional methods, the programme provides results with following major features: (sub-)pixel accuracy (<0.392mm), significantly more objective, based on clinically relevant primary reference, solely based on radiation field, and significantly more data included. Only standard equipment without any special devices is required.

Paper Number: 0292

SEMI-AUTOMATIC QUANTIFICATION BASED ON HIGH RESOLUTION COMPUTED TOMOGRAPHY IMAGES

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Paracoccidioidomycosis (PCM) is a systemic mycosis that causes sequelae in the lungs. Our objective is to develop an algorithm capable of performing semi-automatic quantification of the regions affected by fibrosis and emphysema. Were used 10 HRCT scans. A specialist in radiology subjectively estimated the amount of fibrosis (scale of 0-5 corresponds to the percentage of each lobe affected) and emphysema (1-5 scale with respect to the involvement of 0, 25, 50, 75 or 100% of lung) in the exams. Developed algorithms were able to distinguish sequelae regions using pixel densities in the image. First we determined the threshold interstitial of lung of form manual (-920HU for emphysema and 70HU for fibrosis), then were applied morphological procedures to the image. For emphysema quantification, first operation was majority, followed by erosion and dilation. To fibrosis, first operation was bridgening followed by filling. Finally, we compared the quantification performed by the radiologist and the semi-automatic quantification. A virtual phantom was used for algorithm validation. Real values given by phantom were compared with values obtained by the algorithm, and the largest obtained difference was 10%. Between the quantifications subjective and semi-automatic, there was a concordance of 58% for fibrosis and 80% for emphysema. We observed that radiologists overestimate the areas affected by the structures, due to the subjective visual assessment. The methodology presented in this work is of great use for the semi-automatic quantification of PCM consequences, mainly because few papers are encountered in the literature that relates aspects of this disease on HRCT.

Paper Number: **0394**

SENSITIVITY MAPPING AND SPATIAL RESOLUTION ANALYSIS IN AC BIOSUSCEPTOMETRY

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The Alternate Current Biosuceptometry (ACB) is a biomagnetic technique, which evaluates different parameters related to the gastrointestinal tract through the external monitoring of ferromagnetic materials used as markers or tracers. This technique uses two pairs of induction/detection coils to excite/monitor the magnetic material ingested and/or fixed to the gastrointestinal tract. The signal produced enables the formation of images, relating to the pixel tone with in the magnetic field variation. Using computational techniques, it was possible to form phantom images, leading this technique to a next level, thus revealing the need for signal processing and image analysis of this system.

This work analyzed the spatial resolution of ACB sensors, correlating two established methods in spatial resolution analysis, the Modulation Transfer Function (MTF) and the Full Width at Half Maximum (FWHM) using for this the Point Spread Function (PSF). From the PSF acquisitions, it was possible to quantify the sensors resolutions by both methods and it is also possible make a sensibility map. Will be analyzed different diameters sensors to obtaining the correlation between the two methods. With these methods and the sensibility map it was possible to evaluate the ACB sensors resolution, sensibility and reach, in order to optimize the sensors application according to the measurement to be performed.

Paper Number: 0344

SEQUELAE VOLUME ESTIMATION BASED ON X-RAY PLANAR IMAGES.

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Tuberculosis (TB) caused by Mycobacterium tuberculosis is the most important mycobacterial species from the public health viewpoint. TB can cause pleural effusion, atelectasis, pulmonary condensation and even after effective treatment. TB sequelae such as fibrosis and emphysema can affects life quality in many ways. At clinical practice, evaluation of lung tissue is subjectively made by radiologists using X-ray examinations and / or high-resolution computed tomography (HRCT). The objective was to create an algorithm to estimate the volume of the sequelae of TB examinations in conventional X-rays, since these imply lower dose to the patient and are more affordable than a CT scan, finding an equivalence with HRCT. By quantifying retrospective examinations of healthy lung HRCT, a pattern of volume variation was found. Three Gaussians were used fit the volume pattern, and a rotation of the affected area is made to estimate the sequelae volume. A radiologist delimited affected sequelae areas in 50 X-ray examinations of the chest of patients with TB. To validate the method, 20 X-rays and HRCT from the same patient were used. Sequelae measurement by the two methods showed no significant differences to a degree of 20%. Thus, the created algorithm is able to estimate, from X-rays, the volume of lung area affected by the TB sequelae in an acceptable manner, enabling monitoring of the evolution of TB during certain treatments without the need for numerous HRCT scans.

Paper Number: 0198

SHEAR WAVE ELASTOGRAPHY IN CHARACTERIZATION OF LIVER TUMOURS

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OBJECTIVES

To evaluate the role of shear wave elastography (SWE) in the characterization of liver tumours and to compare the tissue elasticity between hepatocellular carcinoma (HCC), liver metastases and normal liver.

MATERIAL AND METHODS:

Patients referred for multi-phasic CT liver from the last eight months were screened and the following groups were identified: newly diagnosed HCC, liver metastasis and control (patients with no HCC). SWE was performed on the selected patients using a shear wave ultrasound machine (Aix-plorer, SuperSonic Imagine, France) with liver scanning protocol. Curvilinear SC6-1 probe was used to acquire the ultrasound images in B-mode and tissue elasticity in kPa.

RESULTS

40 patients (29 male, 11 female, aged 58.2±12.9 years) were recruited in the study. 14 HCC patients (16 lesions), 10 liver metastases patients (11 lesions) and 16 control patients completed the SWE examination. The mean, maximum and minimum elasticity were 48.1, 54.6 and 30.5 kPa, respectively for HCC; 51.4, 54.6 and 43.0 kPa, respectively for liver metastases; 27.1, 30.5 and 23.1 kPa, respectively for control patients. There were significant differences ($p<0.05$) in tissue elasticity between the HCC and control groups, as well as the liver metastasis and control groups. However there was no significant difference between the HCC and liver metastasis groups.

CONCLUSION

SWE provides a non-invasive, quantitative and non-radiation method to characterize liver tumours based on the tissue elasticity information. However it was still in the early stage to differentiate between HCC and liver metastases ambiguously.

Paper Number: 0249

SKIN MARGINS FOR IMRT OPTIMISATION: HOW MUCH IS ENOUGH?

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The pitfalls of optimisation of IMRT plans where the PTV approaches the body contour are widely known. A popular technique employed to avoid the generation of erroneously high fluences is to modify the optimisation volume by subtracting a margin from the skin surface. Margins between 3 and 5mm are reported, but it is unclear whether these margins can be safely reduced to improve PTV coverage.

IMRT planning was carried out using a Varian Eclipse TPS, with the Anisotropic Analytical Algorithm (version 10.0.28). Optimisation was carried out using PTVs with skin margins in 1mm increments from 0 to 5mm followed by fluence smoothing. TLD measurements were taken at the surface of a semi-cylindrical water equivalent (WT1) phantom. Isocentre shifts from 2 to 5mm were made to model the effect of setup uncertainty. This experiment was repeated without fluence smoothing.

For the smoothed plans, reducing the skin margin improved PTV coverage, but increased volumes of dose greater than 105% but still keeping within 107% maximum. The 107% maximum was achieved even with a 0mm skin margin, but only with aggressive optimisation, leading to high surface fluences and decreased dose fall-off away from the PTV. Surface dose measurements with TLD agreed with TPS calculated doses (within measurement uncertainty). Isocentre shifts lead to significant increases in the maximum dose for PTVs with small and zero skin margins. Unsmoothed plans lead to erroneously high doses for small skin margins.

Paper Number: 0387

SPECTROSCOPIC ASSAY OF 511KEV ANNIHILATION RADIATIONS FOR CALIBRATION OF 90Y GLASS MICROSPHERE

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^{90}Y microspheres (^{90}Y-MS) products are often used in radioembolization for treatment of liver cancer. The microspheres can be made of ceramic (glass) material, ion exchange resins and impregnated with material that emits beta particles upon neutron activation. In this study, a non-destructive spectroscopic assay was employed due to a newly updated low uncertainty positron branching ratio of ^{90}Y that emit 511 keV annihilation radiations. ^{90}Y decays over 99.98% of the time via β- decay to the ground state of ^{90}Zr. A small fraction of the radionuclide (0.01%) beta- decays to the excited 0+ state of ^{90}Zr, which subsequently decays to the ground state via internal conversion, internal pair production (e^+ e^-), or two-photon de-excitation. The miniscule internal pair production branching ratio is

(31.86 ± 0.47)*10-6 and can be useful for the non-destructive assay of ^{90}Y. Production of glass particles was performed using the Tehran Research Reactor and calibration was performed using HPGe. The basic technique involved counting the gross number of gammas detected in 511 keV (annihilation) peak and subtracting the bremsstrahlung continuum and environmental peak at 511 keV. The detection of the 511 keV annihilation radiation produced from the positron decay of ^{90}Y was evaluated with three experiments. In the third experiment, γ spectroscopy in longer than after neuton activation was performed to determine environmental peak at 511 keV. The comparison of two measurements with activity from dose calibrator was performed and relative errors were 12.7% and 21% for two elapsed times, 4 days and 11 days, respectively.

Paper Number: 0146

STANDARDIZATION OF THRESHOLD INTENSITY VALUE FROM 18 F FLUORO-DEOXY-GLUCOSE- POSITRON EMISSIONTOMOGRAPHY (18F-FDG PET) IMAGES FOR TUMOR VOLUME CALCULATION- A PHANTOM STUDY.

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OBJECTIVE
Estimation of metabolic tumor volume (MTV) from 18F-FDG PET image is a challenging task. We have standardized the method to determine threshold intensity value using locally fabricated phantom.

METHODS AND MATERIALS
We filled the phantom (cylindrical phantom having six spherical spheres of diameter ranging from 1.10 cm to 1.93 cm) on different occasion to have 6:1, 7:1, 8:1 and 10:1 sphere to background (S/B) activity concentration ratio using 18F-FDG. These ratios were from 154 lesions site (42 lymphoma patients). 18F-FDG PET/CT images data were acquired and volume of spheres was calculated by the help of RT_Image software. It was done by drawing by Region of Interests (ROIs) on every slice at different threshold value ranging from 40% to 75% to the maximum standardized uptake value (SUVmax) of the spheres and then compared with known volume.

RESULTS
Threshold intensity value of 40% to SUVmax was suitable for sphere of diameter greater than 1.83 cm, 60% for diameter less than 1.83 cm and greater than 1.35 cm and 75% for diameter less than 1.35 cm. We found almost similar results at four different S/B ratios.

CONCLUSION
The standardized threshold intensity values determined from 18 F-FDG PET images of our phantom study is dependent on the diameter (size) of the spheres but is independent of S/B ratios.

Paper Number: 0082

STRATEGIES FOR THE SUPPRESSION OF CT ARTEFACTS AS A RESULT OF HIP PROSTHESES IN PELVIC RADIOTHERAPY - A CRITICAL REVIEW OF LITERATURE

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PURPOSE

To review published literature describing the various MAR (metal artefact reduction) strategies employed as best practice to suppress CT artefacts caused by single and bilateral hip prostheses. No recently published reviews have been identified. The management of gross CT artefact is important for the accurate evaluation of dose deposition in external beam radiotherapy, particularly as planning systems more routinely employ algorithms that rely on biological and volume-based plan optimisation, which is dependant on the accurate representation of anatomical information.

METHOD AND RESULTS

A comprehensive literature search publications between 1998 and 2013 using specific keywords yielded 210 items of which 28 were considered relevant to the research. The methods described include linear interpolation of re-projected metal traces (LI), multi-dimensional adaptive filtering of raw data (MAF) and metal deletion techniques (MDT). Their performance is summarised, with particular emphasis on their efficacy in replacing missing CT data with ‘best-fit' surrogates that more accurately represent the real situation and offer an improved dataset for both the delineation of anatomical structures and the calculation of dose deposition and treatment plan evaluation.

CONCLUSION

The critical appraisal of literature forms the basis of extended research in the field and offers practical advice on current best practice and the design and implementation of improved correction strategies to augment the planning process and improve the outcomes for patients with metal hip prostheses receiving radical radiotherapy in the pelvic region.

Paper number **0110**

STUDY AND CALCULATION OF THE DEPTH-DOSE TO TREAT PROSTATE CANCER BY THE BNCT METHOD USING THE EPITHERMAL NEUTRON SPECTRUM OF THE MIT AND BMRR REACTORS

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Dose calculations during boron neutron capture therapy (BNCT) as a curative treatment of prostate cancer was studied in this paper. The depth-dose distribution in the prostate cancer and adjacent tissues was evaluated using MCNP and Geant4 Monte Carlo computational codes. The source used in these simulations was the epithermal neutron energy spectrum of the MIT and BMRR reactors. The calculations suggested one result: the depth-dose in the prostate cancer depended heavily on the boron-10 concentration, the flux and the shape of the epithermal neutron external spectrum. The total dose in prostate gland was estimated over the range of 5-21 Gy/h. The dose and energy spectrum of the secondary particles produced in nuclear interactions were also calculated and evaluated. It was shown that using BNCT method by the epithermal neutron spectrum along with other methods is very important for the treatment.

Paper Number: 0269

STUDY OF ELECTRON BACKSCATTER FACTOR IN HIGH ENERGY ELECTRON BEAMS FROM A LINEAR ACCELERATOR

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The presence of metallic heterogeneities in an electron beam increases the dose at the tissue interface during radiotherapy due to short range of the backscattered electrons and it needs to be studied dosimetricaly for the effective use of electron beam therapy in clinical practice. In this study the electron back scatter factor (EBSF) for the nominal electron beam energies of 6, 9, 12 and 15 MeV where measured in a solid water phantom using parallel plate ionization chamber. The variation of EBSF with scattering material thickness and depth of scattering medium where analyzed. The aluminum (Al) metal sheets were used as scattering material, which is having atomic number equivalent to that of bone and Solid water were used as scattering medium. The back scatter factor is found to increase with increase of scattering material initially and reaches a saturation value and remains constant thereafter with increasing scattering material thickness. The saturation thickness depends -upon energy of the electron beam. A maximum back scattering dose contribution of 6.96% (3 mm of Al), 4.98% (9 mm of Al), 4.25%(8 mm Al) and 2.5%(6 mm Al) where observed for the beam energies of 6, 9, 12 and 15 MeV respectively. The EBSF found to decrease with increasing depth of scattering medium. This EBSF varies with energy, atomic number of the medium, thickness of the interface and depth of the interface etc. The results of the present study can be used in predicting the increased dose at the tissue interfaces during electron beam radiotherapy.

Paper Number: 0225

STUDY ON EPITHERMAL NEUTRON SOURCE USING BE(P,N) REACTION WITH PROTON ENERGY OF 16MEV

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At Kyoto University Research Reactor Institute(KURRI), we have been performed over 450 clinical studies of Boron Neutron Capture Therapy as of April 2013. On the other hand, cyclotron-based epithermal neutron source was installed at KURRI on December 2010 and first clinical trial in the world using accelerator-based neutron source was performed on October 2012. We selected proton energy of 30MeV because of preventing the blistering on beryllium target. However, it is desirable to reduce the proton energy as low as possible in terms of the activation of a moderator, tritium production in cooling water, the whole body exposure.

In this study, protons with the energy of 16MeV, which produce neutrons with the energy of 14MeV corresponding to threshold energy of tritium production, were selected for the design of a moderator of BNCT. We designed the moderator using Be(p,n) reaction in order to fulfill the criteria prescribed by IAEA-TECDOC1223 and estimated the necessary proton current for BNCT. Furthermore, depth dose distribution in water phantom and whole body exposure for patient were calculated using neutron transport code of MCNPX.

The optimum materials of moderator are iron for reducing the neutron energy and aluminum with calcium fluoride for shaping epithermal neutron region of around several tens keV.

It was found that proton current of 1.8mA was needed in order to obtain epithermal neutron flux of 1.0x109 (n/cm2/s) and tumor dose at the depth of 9.0, 6.5 cm were 10,25Gy-eq, respectively.

Paper Number: 0361

SYNTHESIS OF AN APATITE BASED NANOCOMPOSITE FOR BREAST CANCER DIAGNOSIS AND TREATMENT

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Different approaches for tumors diagnosis and treatments have been widely discussed during the last years. Magnetic nanoparticles provide a new range of ideas as drug delivery systems and treatment by magnetic hyperthermia. These materials can also be used in consolidated methods like Magnetic Resonance Imaging (MRI).

Such nanoparticles can also be coated with a biocompatible polymer, like chitosan, and modified with apatite nanocrystals. This surface modification can make the nanoparticles more attractive to some cancer cells than to healthy tissue. So this work purposes the synthesis of a composite based on Mn and Zn ferrite nanoparticles, coated with chitosan and further modified by apatite nanocrystals.

The ferrite nanoparticles were synthesized by the co-precipitation method and structural properties of the materials are controllable depending on synthesis parameters and Mn/Zn ratio. The nanoparticles were then covered by chitosan by the multiple emulsion technique. This procedure was efficient and does not causes notable changes on particles microstructure. The modification of the polymeric surface with apatite was performed by an in situ nano-precipitation technique. The size and amount of apatite is also well controllable trough the synthesis parameters. Composites with spherical shape diameter of 100nm up to 250nm can be obtained depending on modification degree with apatite.

Paper Number: 0071

TARGET DOSE VERIFICATION IN GAMMA KNIFE: COMPARISON OF IONIZATION CHAMBER, DIAMOND DETECTOR AND RADIOCHROMIC FILM MEASUREMENTS

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INTRODUCTION

To measure of absorbed dose for Leksell Gamma Knife unit.

MATERIALS & METHODS

A PMMA polystyrene head phantom (spherical outer diameter 16 cm) was specially designed and fabricated with provision for different detectors and film. CT images of phantom containing detector were taken with Lekshell frame and these images were transferred to Leksell Gamma Knife treatment planning system (Gamma Plan, Version9.0). Coordinates of center of detector was noted. The detectors and EBT3 film were inserted in polystyrene head phantom was positioned at unit center point (UCP). Detector was irradiated and charge was collected using electrometer. For ionization chamber reading was corrected for variation in temperature and pressure and charge leakage .Film analysis was carried out using Epson 10000 XL flatbed scanner. Net pixel value of radio chromic film was measured. Film was calibrated using Cobalt -60 beam. Absorbed dose was estimated for 18 mm collimator helmet.

RESULTS

Values of absorbed dose rates measured using these three detector systems are in good agreement to one another within 2%.

Table 1: Comparison of absorbed dose rates measured using ionization chamber, diamond detector, TPS and radio chromic film

Ionization chamber A	Diamond detector B	Radio chromic film C	Absorbed dose rate Calculated by TPS
(Gy/min): A	(Gy/min): B	(Gy/min): C	(Gy/min)
1.529	1.557	1.543	1.529
% Difference between A & B 1.79		% Difference Between A & C 0.88	

CONCLUSIONS

This study indicates that dosimetry of gamma knife can be done either by small volume ionization chamber or by diamond detector.

Paper Number: 0157

TECHNICAL COMPARISON OF TEXTURE ANALYSIS METHODS IN THE CLASSIFICATION OF BREAST CANCER SUBTYPES

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PURPOSE

Texture analysis (TA) can improve the specificity of breast magnetic resonance imaging (MRI) by describing spatial distributions of grey-level pixel intensities. Co-occurrence matrices (COM) are second-order statistical methods commonly used in TA in medical imaging, using pixel pairs to generate over 200 texture features. First-order statistics (e.g. max-min methods) use signal intensity extremes and are computationally simpler, with fewer descriptive texture parameters. This study compared identification and classification capabilities of each technique in patients referred for a routine staging breast examination.

METHODS

Patients were scanned on a 1.5T Siemens Avanto scanner using a dedicated breast coil. TA was performed using either MaZda (COM) or custom written software (max-min) on 2-minute post-contrast images. Regions of interest were placed within the lesion and in healthy contralateral breast tissue. Mann Whitney U statistical tests were performed on raw texture feature values, with comparisons made between healthy and malignant tissue, and between each cancer subtype.

RESULTS

A total of 195 lesions from 130 patients were included (110 ductal, 69 lobular, 11 DCIS, 5 tubular). Significant differences in texture features were demonstrated between normal and malignant tissue using both TA methods ($p<0.001$).

Comparing subtypes of cancer, max-min showed statistically significant differences between features in all comparisons ($p<0.02$). The COM showed significant differences ($p<0.001$) in all but lobular vs. DCIS comparison ($p=0.450$).

CONCLUSIONS

The max-min technique can differentiate between normal and malignant tissue and also between different subtypes of breast cancer. This technique is less computationally demanding and requires interpretation of fewer texture features.

Paper Number: 0279

TEXTURE-BASED AUTOMATED QUANTIFICATION OF INTERSTITIAL LUNG DISEASE (ILD): CORRELATION WITH VISUAL SCORE

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PURPOSE
The quantification of disease patterns in the lung parenchyma remains a challenge. The texture analysis algorithm 3D-AMFM (Adaptive Multiple Feature Method) was applied. We checked for the statistical accuracy and reliability by standard tests compared to visual scoring.

METHODS
Based on a Bayesian classifier, a training data base including texture patterns (normal, ground glass, honey combing, emphysema) from 1300 volumes of interest (VOIs; 15x15x15 pixels) of 47 selected patients with mixed ILDs was built up. Another 18 patients with CT pattern of usual interstitial pneumonia (UIP) (n = 9) and nonspecific interstitial pneumonia (NSIP) (n = 9) were independently analyzed and visually quantified at 5 pre-established levels by 3 radiologists (7years, 15years, 25years experience). Same CT-scans were analyzed with 3D-AMFM. Wilcoxon test was used to correlate between visual scores and computed results.

RESULTS
The mean extent of honey-combing, ground-glass and emphysema was 5.4%, 43.5% and 2.1% by visual score and 19.4%, 44.3% and 0.6% by 3D-AMFM, respectively. There was close correlation between visual score and 3D-AMFM for the extent of ground glass ($p= 0.546$) and emphysema ($p = 0.099$), but worse for honey-combing ($p = 0.000837$).

CONCLUSION
3D-AMFM system is a promising and effective tool for ILD quantification, showing clinical acceptable correlation with human observer. The overestimation of honey combing by 3D-AMFM is probably caused by small vessels and airways. The continuing development of the feature data base and the inclusion of further pathologic texture patterns will improve quantification of disease and provide objective measures of disease progression.

Paper Number: **0079**

THE 3G/2G POSITRON ANNIHILATION AND OXYGEN CONCENTRATIONS IN DIFFERENT HYDROPHILIC MATERIALS

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The peak-to-peak method was used to calculate the relative yield of 3g/2g positron annihilations in different oxygen concentrations, density and composition of hydrophilic materials used as tissue equivalent phantoms to represent the tumour. This method could be used to introduce a new modality which can locate the hypoxic tumour by a non-invasive technique. A LaBr3:Ce (5%) scintillator was used to detect the 22Na point source spectrum. The highly oxygenated sample produces low relative 3g/2g yield, whereas, the highest relative 3g/2g yield was obtained from the less oxygenated sample due to ortho-positronium quenching. Therefore, new information of the oxygenation level in tumours could be extracted by using 3-photon annihilation.

Paper Number: 0092

THE DESIGN OF A FANO TEST FOR PROTON MONTE CARLO CALCULATIONS

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For simulating the transport of charged particles in matter efficiently, the Monte Carlo (MC) method is based on a technique called Condensed History (CH) which combines Multiple Scattering (MS) theory with the continuous slowing down approximation (CSDA). The accuracy of CH techniques is limited by approximations made in MS theories, the absence of energy straggling during CSDA (in most codes) and additional restrictions in boundary crossing algorithms. To evaluate the overall accuracy of CH, ideal conditions achieving charged particle equilibrium are simulated and compared to the analytic solution of transport equations stated by Fano's theorem. While such test is standard for electron transport algorithms, it has not yet been done for protons. This study designs a new Fano test for proton MC transport. Defining a virtual particle initiating the transport of protons in matter through analogue transport and undergoing regeneration after each interaction, an extension of Fano's theorem is provided, yielding the expected scored proton dose to equal the product of the interaction coefficient and the virtual particles' kinetic energy, both defined by the user. The Fano test for protons is successfully implemented in the MC codes PENH and GEANT4. In a variety of situations, the Fano test yielded an accuracy of 0.1% for both codes, which is a standard value achieved for electrons using PENELOPE and EGSnrc. Such accuracy levels suggest that the transport mechanics of the codes PENH and GEANT4 could yield acceptable accuracy for many applications, such as detector response simulations and heterogeneous media dose calculations.

Paper Number: 0100

THE INFLUENCE OF THE NOVEL CT RECONSTRUCTION TECHNIQUE ON IMAGE QUALITY AND PATIENT DOSE

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The aim of the present study is to assess the image quality and patient dose in terms of CTDIvol and DLP in colon and cardiac computed tomography (CT) examinations, when using adaptive iterative dose reduction (AIDR) reconstruction technique. The study was performed with Aquilion ONE 320-row detector CT of Toshiba Medical Systems. Analysis of two common CT protocols was performed, after optimization applied based on a pilot study. For a number of patient studies CTDI and DLP were recorded and entered into a database. The database included also the exposure parameters, and patient age, sex and weight. Two different approaches were used to assess the image quality. As a first approach, noise level was measured in identical anatomical structures of the clinical images, and as a second, clinical images were scored by experienced radiologists using anatomical criteria suggested in the European guidelines on quality criteria for CT. The preliminary results indicated adequate image quality of clinical images, with good correlation found between measured noise level and scored clinical images. The average CTDIvol and DLP for colon CT were 121.6 mGy and 826 mGy.cm, and 134 mGy and 730.4 mGy.cm for cardiac CT respectively. The effective dose was assessed to 13.1 mSv for colon CT and 6.5 mSv for cardiac CT.

Paper Number: 0024

THE OPTIMIZATION OF X-RAY IMAGE CONTRAST IMPROVEMENT METHODS APPLICATION FOR CORPULENT PATIENTS UNDERGOING CHEST EXAMINATION

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The most vital problem in fluorography chest screening is high X-ray exposure dose (ED) delivered to corpulent patient which sufficiently contributes to annual effective dose. The problem bases on scattered photons noise effect on image quality. The different contrast improvement methods are usually used in clinic practice: the high or low potential technique, air gap or anti-scatter grid (its application increases ED in Bucky factor (BF)). The aim of experiments was search for optimal methods application to improve image contrast (IC) without sufficient increase in ED, using digital software processing (DSP) based on non-liner signal filtering. The experiments were performed at constant 80kV, using the water chest phantom with thicknesses from 12 to 21 cm and aluminum test-objects. The study results demonstrate less effectiveness of anti-scatter grid in achievement of visual contrast threshold 5% compared to image DSP at the same level of ED. Thus, for 12 cm phantom thickness the test-object IC equals to 2.2%. Under the same conditions DSP improved this value up to 5.0%. The anti-scatter grid improved the IC only to 2.6% with dose increase in BF 3.2, and following image DSP improves it to 7.5%. For 15 cm phantom thickness the test-object IC equals to 0.9%, after DSP - 2.8%. The anti-scatter device increases IC to 2.0% and ED in BF 3.1, after DSP the IC equals to 6.2%. The experiments for next 18 and 21 cm phantom thicknesses demonstrated effectiveness of simultaneous application of both anti-scatter grid and DSP methods.

Paper Number: 0233

THE REAL-TIME IMAGE-GUIDED RADIOTHERAPY OF THE LUNG CANCER PATIENTS USING TUMOR TRACKING SYSTEM (XSIGHT® LUNG TRACKING SYSTEM) – THE METHOD PRESENTATION.

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BACKGROUND

One of the main problem of lung cancer radiosurgery is respiratory motion of the tumor. Therefore, radiosurgery of lung tumor requires the implementation of respiratory gating technique or the tracking option in the CyberKnife system (Xsight® Lung Tracking System). The last solution permits track of the tumor without the use of gold markers.

MATERIAL AND METHODS

We analyzed a group of 11 patients who were treated in the Department of Radiotherapy. All printscreans are collected in Planning System. The imaging system consists of dual X-ray tubes fixed to ceiling of the treatment room and x-ray detectors, which are installed in the floor. The images were taken and compared with DRRs from the treatment planning system. The Xsight® Lung Tracking System locates the tumor on the collected images based on density differences and correlate tumor position with patient respiratory cycle to build a Synchrony Model.

RESULTS

The mean value of image acquisitions during one treatment session was 426. The average of the treatment delivery time was 2 hours 05 minutes and 31 seconds. The largest values of tumor displacements in superior-inferior, left-right and anterior-posterior directions were: 15.2mm, 12.1mm and 11.6mm respectively. The mean value of time of image interval was 36 seconds.

CONCLUSION

Xsight Lung Tracking System provides the exact location of the tumor without fiducials. Combined with Synchrony® Respiratory Tracking System can be a very useful tool permits the robot to follow the tumor during irradiation.

Paper Number: 0200

THE RESULTS OF IAEA/WHO TLD-AUDIT AND THE PROSPECTS OF IMPROVEMENT QUALITY ASSURANCE IN RADIOTHERAPY IN UKRAINE

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According to requirements of WHO and ICRU the quality of radiotherapy and the prevention of post-radiation damage the error of dose delivery to the tumor should not exceed ± 5%.

From 1998 Ukraine participates in IAEA/WHO postal TLD audit of quality dose calibration. During 1998-2012 there were 302 checks of the dose calibration for 95 radiotherapy Units. The significant part of TLD audit results was not successful. After first stage about 32 % radiotherapy beams were outside the acceptance limit of ± 5%, while for 15 % radiation beams – the errors of dose delivery were outside ± 10%. After two stages of TLD-audit only 80 % of radiotherapy units had the dose delivery in the acceptance limit ± 5 %. The most of the errors were associated with using of outdated clinical dosimeters (type 27012) for dose calibration and the low qualification training of medical radiation physicists.

In frame of the national IAEA TC-project (2012-2013) the 25 Ukrainian Oncology Centers got the significant technical support: clinical dosimeters UNIDOS E and standard water phantoms. Sixty medical physicists had a possibility to improve the knowledge and capacity on 3 IAEA training courses. After these actions for the hospitals with previous bad results TLD audit the results in 2012 became more better – the errors were within acceptable values ± 5 %.

Currently, the most important tasks are the creation of national TLD audit network, which should be mandatory for all oncology centers and the training courses for medical physicists on regular base.

Paper Number: 0335

THE ROLE OF HEALTH MANAGERS IN PROMOTING MEDICAL PHYSICIST IN AFRICA

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ABSTRACT

Background: The International Atomic Energy Agency (IAEA) has greatly improved the training of Medical Physicists and radiation scientists in most of the African countries. As defined in the IAEA BSS, the sole aim is to ensure safety and security of all radiation sources, to safeguard the radiation workers, members of the public, the environment and the patient when it comes to medical practices against accidental exposures. With this background, in Africa it is mandatory for each IAEA member state to have a regulatory body to regulate the use of ionising radiation in the existing practices in the entire country. In hospitals, with the support of the Health managers, it is the work of the Medical physicist to ensure that safety and protection is paramount. However, the regulators should over see the safety and protection of medical practices in addition to others elsewhere in the country at a national level. In the hospitals there is a need for collaboration among the Medical Physicists, hospital managers and the regulators for effective utilization of the use of ionizing radiation in medicine. This research aimed at analysing the current scenario and collaboration among regulators, Medical Physicists and hospital managers in the safe use of ionizing radiation in medical Practice in IAEA African member countries.

OBJECTIVES

To assess the current levels of participation and collaboration among regulators, Medical Physicists and hospital managers in the safe use of ionizing radiation in medical Practices in IAEA member states in Africa.

Paper Number: 0294

THEWHOLE-BODY DOSE TO NUCLEAR MEDICINE STAFFBYUSING TLD AND OSL

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AIM

Occupational radiation doses to the nuclear medicine department staff at Akdeniz University hospital were assessed by thermoluminescence dosimeter (TLD) which is the national (supplied by Turkey Atom Energy Agency, TAEK) and the optically stimulated luminescence (OSL-BeO) dosimeter supplied by private organizations at constant evaluation period for a year.

MATERIALS AND METHODS

This study was based on 6 experiments by OSL-BeO and 5 experiments by TLD for a year. TLD and OSL simultaneously distributed to staff with two month periods. The dosimeters were distributed to 2 technicians who work on positron emission tomography (PET), 1 physician and 6 technicians who work on the other areas of the nuclear medicine department.

RESULTS AND CONCLUSION

In a typical yearly workload, the average annual dose to the whole body for all staff by OSL-BeO and TLD was 0.80mSv and 0.34mSv respectively. According to the dose results of two type dosimeters the annual dose limit of staff not exceeded the recommended occupational whole body dose of 50 mSv. OSL-BeO dose results were higher than TLD. When the average annual dose of each staff' was individually analyzed, the average dose of PET technicians were higher than other staff. The average dose and standard deviation of two technicians were 1.87+ 0,418mSv and 2.25+0,263mSv by OSL-BeO, 0.92+ 0,532mSv and 1.28+ 0,503mSv by TLD respectively. The review of literature was shown that OSL-BeO was more sensitive than TLD for measuring occupational radiation dose.

Paper Number: 0033

TO STUDY THE VARIATION OF DOSE IN BLADDER AND RECTUM DUE TO VARIATION IN POSITION OF THE FLETCHER-SUIT-DELCLOS APPLICATOR IN SUCCESSIVE APPLICATION AND ITS CONTRIBUTING FACTORS IN HIGH DOSE RATE (HDR) INTRACAVITORY BRACHYTHERAPY.

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INTRODUCTION

Most of the Ca cervix patients are found to be present with advanced stage disease and require radiation Therapy.

The Fletcher-suit-delclos applicator is used. The prescribed dose 7Gy per fraction is given to the Point 'A' sparing rectum and bladder.

50Gy dose is delivered to the entire pelvis from external radiotherapy and 3 applications of ICR 7Gy per fraction in 3 week

MATERIAL AND METHOD

The plans of two successive ICR are analyzed, Variation of dose in bladder and rectum in these two plans are compared and contributing factors are analyzed.

RESULT AND DISCUSSION

It is observed that the dose variation between two applications in bladder and rectum is found to be as high as 40 % (2.8Gy) and 27.43 % (1.92Gy) of 7Gy respectively.

In Bladder 10 (9.09%) patient got more than 20%, 28 (25.45%) patient got (10- 20) %, 20 (18.18%) patient got dose variation of (5 -10) % and 52(47.27) patients have dose variation less than 5%.

In rectum 14 (12.73%) patient got more than 20%, 27 (24.55%) patient got between (10- 20) % and 33 (30%) patient got (5 -10) % dose variation and 36 (32.72) patients got dose variation less than 5%.

CONCLUSION

Dose variation as high as 40% and 27.43% is found in bladder and rectum. Which is significant

Positioning of applicator, digitization of ovoid and planning are found to be most important factors contributing to dose variation. Careful procedure reduce the errors. Planning and delivering of radiation dose without simulation may result inaccurate doses to the target and critical Structures.

Paper Number: 0137

TOTAL BODY IRRADIATION (TBI) – PRELIMINARY EXPERIENCE ON CLINICAL IMPLEMENTATION

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Total body irradiation (TBI) is used as a conditioning regimen prior to bone marrow transplantation (BMT). The execution of a lateral irradiation technique for two patients receiving TBI is discussed, based on preliminary dosimetric data. TBI is carried out in a Clinac 600 CD linear accelerator at 4.0M focus skin distance, MU repetition rate 100 MU/min, along with a locally fabricated acrylic beam spoiler and a beam flatness filter. The measured dose/MU at 4.0M source skin distance is 0.06836 cGy/MU. The attenuation factors of flattening filter (FFF) and beam spoiler (FBS) are 0.970 and 0.962 respectively. The monitor units required for 100 cGy at mid-plane were 2412 MU and 2256 MU respectively for treated 2 patients. The arms positioned along the side of the body compensated well for equivalent lung path length. The estimated doses for the 2 patients by Direct Patient Dosimetry (DPD) with semiconductor measurements on the first 2 fractions (Day1) helped to make minimal changes in compensator plate thicknesses to improve dose homogeneity. Dose estimates of the patients during entire treatment (all 6 fractions) by thermo-luminescent detectors (TLD) showed delivered mid-plane doses to whole body 2.05 (± 7.0%) Gy and 2.00 (± 3.4%) respectively per fraction for the 2 patients. The delivered TBI doses were 12.3 Gy and 12 Gy for the planned dose of 12 Gy/6 fractions. With a dose rate of 6.87cGy/min, for 12Gy/6 fractions calculated BEDkidney was equal to 20.2Gy. More homogeneity in dose delivery is observed with our TBI technique and treatment execution.

Paper Number: 0203

TOWARDS A NATIONAL PERFORMANCE MEASUREMENT SYSTEM FOR RADIOLOGY DEPARTMENTS: MEDICAL PHYSICS INPUT THROUGH QUEUEING THEORY ANALYSIS AND SIMULATION

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Queuing theory analysis of patient waiting times and resource utilisation in hospital facilities has been employed in many studies to offer insight into potential improvements in service efficiency. Data gathered from services has also been used to generate mathematical simulations of workflow to answer theoretical questions for planning purposes. The installation of PACS, RIS and other hospital information systems in most major hospitals now means that patient throughput data has become more easily available.

While the majority of the literature has focussed on emergency departments, surgery and radiotherapy facilities, little analysis has been conducted on the radiology department, regarded as a core facility within the hospital whose efficient utilisation is necessary for overall hospital efficiency. Thus, new and inventive initiatives are being sought for improved efficiency in radiology services.

In this study, radiology activity was quantified by analysing patient order, scan and report time data for different modalities (MRI, Ultrasound and CT). The activity metrics used were 50th, 75th and 90th percentile of patients examined and reported, in addition to total numbers of patients waiting, backlog and length of stay. Computational simulations were devised to model scheduling and cancelation patterns, towards identifying improved efficiency in modality workflow. With the current implementation of Ireland's National Integrated Medical Imaging System (NIMIS), this study serves as pilot work for a national radiology performance measurement system. Hence, this highlights an opportunity for medical physics departments, through use of the available mathematical and analytical skills, to become further involved in radiology operations.

Paper Number: 0209

TRACE ELEMENTS IN ESSENTIAL HYPERTENSION

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In order to investigate if, and which, trace and major elements are involved in essential hypertension we compared the trace elements concentrations in the blood of "spontaneously- hypertensive" rats - [SHR] (representing essential hypertension system) and "normotensive" Wistar Kyoto rats [WKY]. Both the rats types are very similar and any changes in the trace elemental concentrations would be due hypertension only, Five (SHR) were selected for our investigations. were approximately 16 weeks old and fully mature. As controls, genetically similar five "normotensive" (WKY) rats were used. All the rats were of pure breed and grown in our laboratories under similar conditions, and received a standard diet including vitamins and minerals. Approximately 5 ml blood samples were drawn from each of the animals. These were frozen, freeze-dried, crushed into fine powder and pressed into pellets using a hydraulic press. Ultra clean boric acid was used as the binding and backing material. Bovine Liver (NIST) and Mussel powder (NIES) were used as "standards" and were also pressed into pellets with the boric acid backing. Determination of different trace elements in various samples was conducted in a commercial Energy-Dispersive X-Ray Fluorescence Spectrometer (ARL- Model 8420) which uses a Rhodium X-Ray tube. A number of elements, Na, Mg, P, Cl, S, K, Ca, Fe, Cu, Zn, Rb and Br, ranging in concentrations from a few ppm to around 1 % were measured in both types of blood samples. These results would be presented and discussed.

Paper number 0317

UNDERGRADUATE MEDICAL PHYSICS EDUCATION IN SOUTH AFRICA

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INTRODUCTION

Medical Physics Education in South Africa (SA) has been established for some four decades, but in the late 1990's it was realised that the bachelor's degrees that students had obtained in their undergraduate studies did not properly prepare them for the fourth year of study, BMedSc Honours, a prerequisite for the 24 month Internship. An Introductory degree in Medical Science was proposed at the University of the Free State and a curriculum developed to introduce students to subjects covered in the honours course.

AIM

Assess the outcomes of the BMedSc (Radiation Sciences) degree offered.

COURSE CONTENT

A three year BMedSc course was instituted and the first students were selected into first year in 2002. Standard first year science courses were included in the first year including amongst others Physics, Maths, Chemistry and Anatomy modules. The second and third years had Physics, Physiology and Radiation Science modules which included Radiation Biology and Oncology. The modules were all introductory to the honours courses to be followed.

RESULTS

Over the past 11 years 89 students have enrolled in the course with 14 currently enrolled at undergraduate level (first three years) and 9 at honours level. Some students have changed disciplines and some have failed to complete, but in total 26 of the approximately 100 currently registered Medical Physicists in SA have completed this undergraduate course. Some of these now hold senior positions in both private companies and academic institutions.

CONCLUSIONS

The undergraduate academic program benefits Medical Physics education in SA.

Paper Number: 0207

URANIUM CONCENTRATIONS IN BLOOD-PLASMA OF BAVARIAN FEMALES

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It has recently been reported that the water supply (both for drinking and bottling) in some parts of South Germany, including Bavaria, contains up to 170 ng/L of U [1]. In order to study the effects of this uranium "contamination" in the drinking water on the body burden of U we have measured the U contents in the blood plasma of 25 females from Bavaria. All these women were not taking any drugs or food supplement. The reason that we selected only females for this study was that they were already taking part in another project dealing with the role of trace elements in osteoporosis and osteopenia. Blood samples were drawn from a superficial arm-vein, centrifuged and plasma extracted. The plasma samples were freeze-dried and analysed at the Centre for Forensic Science in Perth, Western Australia by using the technique of Solution-based Inductively-Coupled-Plasma-Mass-Spectrometry (ICP-MS). The U-concentrations in the blood plasma ranged from 7 to 543 ng/L. Unfortunately, we could not find any data on this subject in the literature for comparison purposes.

[1] Bundesgesundheitsblatt-Gesundheitsforschung-Gesundheitsschutz 10 (2009)

Paper Number: 0332

USE OF VMAT IN THE TREATMENT OF B CELL LYMPHOMA OF THE SCALP

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PURPOSE

The benefits of VMAT in the treatment of Head and Neck cancer in terms of conformality and organ at risk sparing have been well documented in numerous publications. However, the benefits in using this modality in the treatment of subcutaneous or peripheral Head and Neck lesions is less well reported. This study demonstrates the application of VMAT using the RapidArc® platform to provide novel planning solutions for three cases at the BWoSCC who presented with extensive Lymphoma of the scalp.

METHOD

In addition to multiple target and organ at risk (OAR) delineation, a series of additional planning structures were created to facilitate dose sculpting. Optimisation parameters were then manipulated to enable the dose constraints to be achieved. Multiple arc treatments utilising the benefits of High Definition Multi-Leaf Collimation (HDMLC) and TrueBeamTM technology were used to produce highly conformal dose distributions.

RESULTS

In all cases the target coverage and dose sparring achieved to the OAR's could not have been achieved with more conventional treatment solutions for these lesions. This significantly impacted on the preservation of organ functionality and hence quality of life for the patients. An overall reduction in delivery time was also realised with beam on times of under three minutes.

CONCLUSION

The case studies demonstrate that the use of VMAT is a viable, effective and optimised treatment solution for patients with these types of lesion when compared to conventional treatment modalities. Using this technology permits adherence to clinical dose constraints with minimal compromise to overall target coverage.

Paper Number: 0067

USING IT-BASED EDUCATION AS A CUE FOR INCULCATING STUDENTS WITH A SENSE OF CREATIVITY

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Biomedical engineering and medical physics students are expected to show specific social competencies, sometimes rarely hardly implantable in purely academic environment. The institutional example of the university and personal example of the tutor are often underestimated, however they play an important role in professional culture of graduates. This aspect of using modern teaching technologies is rarely considered, but the creative approach of the leader implies the creativity of the students. Besides other practical aspects, e-learning, interactive forms, team building or EU-alike applications for project funding, expositions, present in teaching methodology are equally imprinted in students' professional habits. An open-minded attitude, life-long pursuit for novelty and multidisciplinary problem solving were found essential for a modern bioengineer expected to represent the technology in medically-oriented team and to follow the instantaneous progress in both medicine and technology.

The presented approach was implemented and tested in everyday academic practice during 6 years at Multidisciplinary School of Engineering in Biomedicine, AGH University of Science and Technology, Krakow, Poland. This experimental and innovative institution (with scholarship duties equivalent to a faculty) developed his proper teaching methods taking advantages of best practice from three universities, but also from the feedback provided by future employers. Tracking the professional careers of first graduates shows that whether they support raising biomedical engineering in Poland and abroad, or fall to other branches of technology, the creativity is often considered as their main professional attitude.

Paper Number: 0217

USING SYNCHROTRON X-RAY BEAMS FOR MEDICAL PHYSICS RESEARCH

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The brightness, bandwidth, coherence, and polarisation of synchrotron x-ray beams make them a useful tool for both x-ray radiography and radiotherapy research. Such beams are generated using storage ring accelerators which are usually built as a national facility. Within these large scientific infrastructure laboratories there are only a few examples in the world of dedicated instruments working in the field of medical physics. The Imaging and Medical beam line (IMBL) at the Australian Synchrotron is just such a purpose built facility. IMBL was designed and built explicitly to investigate ways to use the unique qualities of its x-ray beam for medical research. The beam line has three experiment/radiation enclosures which cover a wide range of studies, from broad bandwidth, fine structured beam radio-biology projects, to monochromatic (narrow bandwidth) large animal pre-clinical and clinical human imaging. The highly collimated nature of the beams allows spatial modulation with features down to the 10 micron scale. The adjustable power can provide dose rates of kiloGray per second. The high coherence allows phase contrast planar imaging and computed tomography (CT) to be explored in medical radiography. The very bright beams can be exploited for dynamic x-ray imaging. The well behaved and thoroughly understood nature of the generation of synchrotron light from the storage ring also gives these beams the potential for accurate dosimetry investigations, and instrument characterisation in the kilovoltage photon range. This presentation describes the IMBL facility, it's current and planned future uses.

Paper Number: 0041

VALIDATION OF LOWER LIMB RADIOGRAPHY

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Since 2009 the department of orthopedics at the Orbis Medical Centre (OMC) uses a new technique for placement of a total knee prosthesis (TKP). Using the so called SignatureTM Personalized Patient Care (Biomet) an MRI scan of the hip, knee and ankle of the patient is made preoperative. Based on this scan the position of the prosthesis components is determined using a dedicated software tool. One of the goals is to reach a neutral mechanical axis of the leg after TKP placement.

One of the most important methods to determine the quality of the TKP placement is judging the mechanical axis of the leg using lower limb radiography. Goal of this study was to provide insight into the reliability of this mechanical axis based on lower limb radiography. Based upon we can answer the question: "Is it possible to make a sound statement about the TKP placement based on pre and postoperative lower limb radiography?"

To determine the mechanical axis a radiographic analysis protocol was prepared, which showed to be reliable and reproducible. The variation between two radiographs of the same patient was shown to be 1,3°. Related to the surgical range (3° varus to -3° valgus) these radiographs were therefore considered to be sufficiently reliable and can be used to determine the mechanical axis of the leg quantitatively. Based on the surgical range in combination with the variation in radiography, in 90% of the analysed patients the desired surgical outcome was reached.

Paper Number: 0162

VALIDATION OF THE PHANTOM HYDRA FOR QUALITY ASSURANCE OF CT IMAGES AND DOSE EVALUATION OF RADIOTHERAPY TREATMENT PLANS

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Among the most important stages of the radiotherapy planning process, are image acquisition of patient and evaluation of dose distribution. The images of patients are predominantly of Computed Tomography (CT), and can be used to obtain a spatial distribution of densities and chemical compositions of the organs and tissues. The density distribution is established by a calibration curve obtained empirically from CT images of a tissue characterization phantom, which has several inserts of different materials. In 2012, Oliveira built a physical phantom, called Hydra, with which it is possible to obtain both a calibration curve, as evaluate the following quality control parameters: noise, low contrast resolution and CT number accuracy. This work aims to validate the phantom Hydra. Hydra has two regions contained in an acrylic cylindrical container of diameter 30 cm and height 20 cm, filled with water. The first region plays the role of a tissue characterization phantom, allowing to evaluate the CT number accuracy. This region is defined by two acrylic plates and has several cylinders of tissue-equivalent material. The second region allows to analyze noise and low contrast resolution. This region contains only water, defined by a ring of acrylic approximately height 5 cm. Several series of CT images of the Hydra were obtained, varying the acquisition parameters: kVp, mAs and reconstruction filter. The results were compared with those of commercial phantoms.

Paper Number: 0112

WHEELCHAIR TRANSPORT OCCUPANT RESTRAINT SYSTEMS FOR CUSTOM CONTOURED SEATING

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INTRODUCTION

Specialist seating systems are designed and built for posture control, often with little or no consideration to transportation issues, leaving patients dangerously at risk when in transportation.

Although there are a number of ISO (International Organization for Standardisation) standards relating to wheelchairs in transportation, these are market driven, voluntary guidelines and as such there is no legally binding statute. This means that people are being transported in many different ways, and not always safely.

Two types of occupant restraint systems for use with custom contoured seating have been compared. The results show the choice of occupant restraint used is critical to patient safety.

METHOD

Limitations in current practices by transport companies and carers of patients with special seating systems have been recorded.

The constraints imposed by the intended purpose of the wheelchair seating that is provided have been considered.

Two sled tests were conducted, comparing a vehicle mounted occupant restraint system to a wheelchair integrated occupant restraint system.

RESULTS

The kinematic and video data from the sled tests confirmed that a wheelchair integrated occupant restraint system is suited for crashworthy special seating systems for use in motor vehicles. However the wrong choice of occupant restraint can result in extremely unsafe situations occurring.

DISCUSSION

This project highlights the need for wheelchair prescribers to take the initiative in transport related matters. Further work is needed to develop a range of hardware solutions to meet patient needs, based on the constraints imposed by their circumstances.

Paper Number: 0228

X-RAY SCATTERING IMAGING OF BREAST SPECIMEN USING LAUE CASE ANALYZER

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When x-rays pass through an object, they are absorbed, refracted, and scattered. Since x-rays were discovered, we have utilized only the contrast due to the difference of x-ray absorption in the clinical field. In the meantime, various techniques have been developed to extract an object's x-ray absorption, refraction (phase shift), and scatter, either separately or in some combination thereof during the past 20 years. Refraction-contrast, which is based on the difference in x-ray refraction, has been proved to be good at depicting objects that consist of matter with weak x-ray absorption by many researchers. Besides, some researchers have reported the studies on the image contrast due to x-ray scatter using Bragg case analyzer (reflection type) and shown the utility of the contrast. We tried x-ray scatter imaging utilizing Laue case analyzer (transmission type). The experiment was performed at Beamline BL14B using synchrotron x-ray from the vertical wiggler of the Photon Factory in Tsukuba, Japan. The incident x-ray energy was monochromated to 20.0 keV and the object was breast specimen excised during mastectomy. The diffracted x-ray beams were acquired as images. The degree of x-ray scatter was estimated from the expanse of the intensity curve of the each local pixel during Laue case analyzer rotated within the range of diffraction. The acquired contrast due to x-ray scatter was different from that of refraction. It was indicated that scatter and refraction contrasts can be treated complementarily.


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ADDITIONAL ABSTRACTS

The Additonal abstrcats will be published later at the Online version of the Medical Physics International No2 - www.mpijpournal.org

Abstracts database as of 20.July.2013

ICMP 2013

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