IMPACT OF COVID-19 ON MEDICAL PHYSICS IN QATAR

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Abstract — **The history of Medical physics started in Qatar as Hamad Medical Corporation (HMC) grew from three hospitals in the early 1980's, to 15 hospitals in 2021. Qatar Medical Physics Society (QaMPS) started in 2009 as a small group of medical physicists in Hamad Medical Corporation (HMC). The mission of QaMPS is to advance medical physics practice in Qatar and to promote and support the medical physics profession. QaMPS is one of the founding members of the Middle East Federation of Organization of Medical Physics (MEFOMP). The number of Medical physicists grew from 9 in 2009 to 38 in 2021. The number of Medical Physicists per million is about 13. The average number of Linacs, CT and Nuclear Medicine units are 1.9, 22.2 and 4.4 units per million population, respectively. Medical Physicists in Qatar played a significant role during this unprecedented COVID-19 pandemic, both in sustaining its essential role to the healthcare system and in optimizing the preventive effort of humankind in the control of this pandemic.**

Keywords — **medical physicist, radiotherapy, nuclear medicine, diagnostic radiology, COVID-19, Qatar.**

I. Introduction

The history of Medical physics started in Qatar as Hamad Medical Corporation (HMC) grew from three hospitals in the early 1980's, to 15 hospitals in 2021. HMC has invested greatly on the radiotherapy, nuclear medicine and diagnostic radiology equipment. Most of these equipment use ionizing radiation, and involves certain risk for the patients and the medical personnel using these equipment. Therefore, the operation of these equipment should comply with certain requirements in the national radiation protection laws and regulations in Qatar (Qatar Radiation Protection Law, Decree Number 31 of 2002 and Minister of Municipality and Environment Decree Number 4 of 2003 on the Executive Regulations for Law No.31) [1 and 2]. In response to these requirements in diagnostic radiology and nuclear medicine, the radiation safety services of HMC grew from a small Radiation Protection Unit at the Radiology (the name changed to Clinical Imaging) Department in 2000, to a fully functioning Radiation Safety Section within the Occupational Health and Safety Department in 2010. This section was recently renamed to Medical Physics Section (MPS). Similarly, the Department of Radiation Oncology was established in 2004 at Al Amal Hospital. In 2009, the radiation oncology department underwent major upgrade of its facility including the commissioning of new equipment, the implementation of new techniques and modalities as well as recruiting new staff including a team of Radiotherapy Medical Physicists. After the major technology upgradation, Al Amal Hospital had been renamed as the National Center for Cancer Care & Research (NCCCR).

II. Qatar Medical Physics Society

Qatar Medical Physics Society (QaMPS) started in 2009 as a small group of medical physicists in Hamad Medical Corporation (HMC). The mission of QaMPS is to advance medical physics practice in Qatar and to promote and support the medical physics profession and to provide opportunities for education and professional development, while promoting excellence in the profession to achieve the highest standard of patient care [3]. The objectives of the QaMPS are to strengthen and promote Medical Physics in Qatar by:

1. Organizing national and international cooperation work in medical physics and allied subjects;
2. Contributing to the advancement of medical physics in all its aspects, in governmental and non-governmental healthcare organizations; and

Table 1 Total number of medical physicists in QaMPS from 2009 until 2021 and the approximate number in each specialty of Medical physics.

Year	Total Number of medical physicists	Medical Physicists in each Specialty			
		Radiotherapy	Nuclear Medicine	Diagnostic Radiology	Health Physics
2009	**9**	3	-	3	3
2010	**9**	3	-	3	3
2011	**12**	5	-	4	3
2012	**15**	5	-	4	4
2013	**14**	5	1	4	4
2014	**14**	5	1	4	4
2015	**17**	6	1	6	4
2016	**20**	7	1	7	5
2017	**25**	11	2	7	5
2018	**29**	11	3	8	7
2019	**34**	11	3	9	10
2020	**38**	12	4	13	11
2021	**38**	12	4	13	11

3. Representing the medical physics in Qatar at both regional and international levels.

QaMPS is one of the founding members of the Middle East Federation of Organization of Medical Physics (MEFOMP). Currently the president of QaMPS is also the president of MEFOMP until the next election in 2022. QaMPS is also a member of International organization of Medical Physics (IOMP).

The number of Medical physicists grew from 9 in 2009 to 38 in 2021. The medical physicists in QaMPS are not only in HMC but also in other public and private health and academic institutions. Figure 1 shows the increase in the number of medical physicists in QaMPS from its establishment until now in the different specialties of Medical physics. The number of Medical Physicists per million is about 13. This seems a relatively acceptable number, as the average number in the world is about 2.7; 15–20 per million population in the developed countries and 1–5 per million population in developing countries. On the other hand, in many underdeveloped countries this number is close to 0 [4]. Most of the Medical Physicists are expats and locals are only about 15%.

Table 2 shows the approximate number of medical equipment in radiation therapy, nuclear medicine and diagnostic radiology. The number of linac units per million population in Qatar is 1.9 unit per million population. According to the World Health organization (WHO), this number brings just below the first band of countries including Western Europe and North America where the number of Linacs per million population is between 3.3 and 72.8 [5].

It is evident from the Table 2 that the number of CT scanners per million population is about 22.2 CT units per million, which is just about the mean number of CT scanners per million population in the Organization for Economic Co-operation and Development (OECD) countries, which is 22.9 [6].

The approximate numbers of equipment used in the nuclear medicine procedures (including Gamma Cameras, Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT), PET-CT, SPECT-CT and Positron Emission Mammography (PEM)) are shown in Table 2. It is clear that that the number of units per million population is 4.4, which is significantly higher than the average of 2.3 units per million population in the Middle East Region reported in 2015 [7].

Medical physics education in Qatar has been through completion of a BSc degree in Physics or Allied health science followed by a postgraduate degree from abroad. There are no national medical physics academic education program such as BSc or MSc.

Table 2 Approximate number of medical equipment in radiation therapy, nuclear medicine and diagnostic radiology.

Equipment	Total	Unit per million population
Radiation Oncology		
LINAC (one will be installed soon)	4	1.9
Cyberknife	1	
Brachytherapy	1	
Nuclear Medicine		
Gamma Camera	2	4.4
SPECT	3	
SPECT/CT	3	
PET/CT scanner (one will be installed soon)	3	
PEM (will be installed soon)	1	
Medical Cyclotron	1	
Diagnostic Radiology		
MRI systems	30	11.1
CT scanner	60	22.2
Mammography	25	9.3
Standard Radiology	250	92.6
Fluoroscopy and angiography systems	150	55.6
Bone Densitometry	10	2.7

QaMPS worked on the improvement the standards of medical physics specialty in the Qatar's academic and health institutions through regular meeting every three months and conducting training courses, workshops and conferences. QaMPS encouraged the Medical Physicist in Qatar to participate the international medical physics certification board (IMPCB) examinations and also the QaMPS sponsoring the examination fees to all the candidates from Qatar.

III. National Center for Cancer Care and Research

As part of the National Cancer Strategy launched by Her Highness Sheikha Moza Bint Nasser, refurbishment of Al Amal Hospital has been accomplished in 2011. This aims to provide international standard, high-quality cancer care to patient in Qatar. New equipment including advanced systems such as stereotactic radiosurgery with a dedicated magnetic resonance imaging unit for radiotherapy simulation (MR-SIM) were installed. In addition, the department was the first one in the world to commission the GEM RT Open Head & Neck suite (GE Healthcare) for the radiation therapy planning. After the major technology upgradation, Al Amal Hospital had been renamed as the National Center for Cancer Care & Research (NCCCR).

The patient care quality of the Radiation oncology department was demonstrated by the center of competence award from Quality Improvement Quality Assurance Team for Radiation Oncology (IAEA), which reviewed the quality of all the components of the radiotherapy practice at our

center. Also, the department is actively participating every year in the remote beam output audits provided by the MD Anderson Radiation dosimetry services, which independently measure the accuracy of machine calibration.

The robotic couch along with the Exactrac system was introduced in 2013. This helped for the treatment of frameless Stereotactic Radiosurgery (SRS) for patients with intra-cranial lesions of both a primary and metastatic nature. Since then, our intra-cranial treatment was reformed, eliminating the need for the invasive frame-based technique, improving patient safety and satisfaction and increasing the treatment precision.

The department was the first in the region to implement a sophisticated interventional radio-oncological procedure, Magnetic Resonance Imaging Guided Adaptive Brachytherapy (MRI-GABT) in 2014. In addition to MR-GABT, the department of Radiation Oncology initiated a partnership with TomAblate® for the commissioning and early adoption of MR Guided High Intensity Focused Ultrasound (MRgHIFU). The Department was one of the pioneers to introduce the new technology that will substantially improve the quality of care in the treatment of non-invasive treatment/ablation of painful bone metastases. The MRgHIFU system was upgraded for the treatment of uterine fibroids in 2016. This process involved a multidisciplinary team working on clinical practice guidelines and protocols along with on-site specialized support.

The Cyberknife M6 system was introduced in 2016 at NCCCR. This system was the latest technological advancement for robotic radiosurgery and the first of its kind in the region. The clinical implementation process involved the establishment of a dedicated commissioning team following construction of the suite. In addition, a multidisciplinary team established to develop clinical guidelines and process protocols for cranial stereotactic treatments.

More than 60% of the radiotherapy workload is contributed by breast cancer and in an effort to improve the breast treatments, the surface guided radiotherapy (SGRT) was introduced in 2018. This system is currently used for the accurate patient positioning of not only for the breast, but also for other sites such as thorax, abdomen and pelvis. In addition, the deep inspiration breath hold treatments based on SGRT is successfully implemented for left sided breast cancer treatments.

Total Body Irradiation (TBI) treatment technique based on translational couch was implemented in 2018 and our TBI team actively collaborating with the bone marrow transplant unit at NCCCR for the successful bone marrow or peripheral blood stem cell transplantation procedures.

IV. Clinical and Research Activities

Clinical Physicist at Radiation oncology involves in various aspects of medical physics, which includes treatment planning, QA and maintenance of radiotherapy equipment, new protocol and policy development, commissioning and establishing new treatment techniques and radiation safety.

There is no professional certification organization for medical physicist in Qatar. Most of the clinical physicist at Radiation oncology are certified by the professional organizations such as American Board of Radiology (ABR), Australasian College of Physical Scientists & Engineers in Medicine (ACPSEM) etc. The medical physicist who are not certified are encouraged to participate in international medical physics certification board (IMPCB). Lately, the IMPCB is included as one of the acceptable professional certification for the Physicist job at HMC.

In addition to clinical activities, medical physicists are actively involved in research and education, which has been of particular interest in the department of radiation oncology since 2005. Indeed, with the aim of improving patient care, competitiveness and visibility at the national and international level, our department at the NCCCR has implement a research strategy in 2005 including the creation of long-term research projects and building a research team. As such, two medical imaging scientists under the medical physicist family has been recruited and research projects related to the use of imaging to guide radiation therapy has been defined.

Since then, the department of radiation oncology at the NCCCR is heavily engaged in research activities. As part of an innovative research project on the use of MRI as unique method for establishing external radiotherapy treatment plans, several studies have been developed and conducted. One of these studies concerns the characterization of the MR geometric distortion of MRI scanners commissioned for radiation therapy planning. Another study concerns the generation of synthetic CT for MRI-only external beam radiotherapy. Till now these studies has led to the publication of 4 journal papers in 2015, 2016, 2017 and 2018 and several abstracts at international conferences.

As a continuity of these studies, new studies have been developed such as the establishment of a comprehensive QA program for the MR-SIM including the development of a software for automatic QA and the construction of new phantoms using the 3D printing technology. Finally, within the era of Artificial Intelligence (AI), new projects on the use of these tools to automatically predict QA results, contouring, dosimetry are being initiated lately. In support to the research activities, our department has received several grants and continues to actively contribute to international peer reviewed journals across disciplines, of note in the field of MR led research and image guided brachytherapy.

Furthermore, Continuous Research, Education and Advances Meetings at the Department (CREAM) sessions was initiated in 2013 as the education/research meetings of our team. These sessions have evolved further and provided an interesting and valuable source of continuous medical education, specific to the field of Radiation Oncology. Several international speakers were invited to give their presentations. The CREAM sessions serve as a platform to further strengthen the exchange of information, knowledge, and scientific achievements between the different members of our multidisciplinary teams. The CREAM sessions take place monthly twice.

In addition to research activities, education has been a high priority in our department. As such, year 2015 saw the establishment and roll out of a Radiation Oncology structured curriculum and school program for medical oncology fellows with multi-disciplinary input from the radiation oncologist, medical physics and radiation therapist teams.

V. Impact of Covid-19 on Radiotherapy Medical Physics ntroduction

Medical Physicist group working at NCCCR in HMC, which is the only hospital in Qatar providing comprehensive cancer care and radiation therapy, takes part with the rest of the world in the fight against COVID-19 pandemic while continuously delivering treatment and care to its patients.

It has been anticipated that during the outbreak, NCCCR may be impacted by significant staff shortages that could potentially affect its ability to deliver routine cancer care to patients in the form of Radiation therapy. Accordingly, at the start of the escalation phase of the COVID-19 pandemic, mitigation measures have been implemented across HMC, NCCCR and the Radiation Oncology Department, to minimize risk of exposure to the novel coronavirus, protecting Staff and Patients.

As an immediate response to the pandemic, a dedicated 'Task Group' was created, with representatives from every Team in the Department (doctors, physicists, therapists and nurses), who will work closely together with the Infection Control team monitoring the crisis, identifying active issues and planning strategies as the pandemic evolves.

The Task Group developed a Clinical Response Plan, which contains general measures introduced at the beginning of the outbreak, to protect patients and staff. It moreover, seeks to stratify appropriate adjustment of the clinical service, dependent on the staffing level. As the pandemic evolves, this document will be reviewed regularly and adjusted accordingly.

In developing this plan, the following principles were observed:

- Protection of staff and patients from COVID-19 infection by applying risk mitigation strategies;
- Where possible, those treatments that provide a chance of long-term cancer control or cure will be prioritized;
- Treatments aimed at palliation alone or a minimal extension of life may have to be temporarily deferred or suspended during the peak of a COVID-19 outbreak;
- Patients who have commenced a course of radiation therapy should be prioritized and supported in completing their treatments.

This Clinical Response Plan also aims to describe recommended staffing adjustments. The teams - all medical and non-medical Staff were divided in two separate entities, i.e. two Teams: Team 1 and Team 2, working in 2 shifts daily. These shifts are fixed, i.e. either only in the morning or in the afternoon, without any swapping or contact between the two Teams, to minimize any potential spread of the infection between them, patients, as well as with other Team members across our Department. The department continued providing internal educational presentations under the department's Qatar Council for Healthcare Practitioners (QCHP) accredited educational activities. These are conducted virtually through Microsoft Teams.

Lastly, at the research end, we submitted a research proposal to the Institutional Review Board for the use of Low dose radiation therapy (LDRT) in the treatment of critically ill COVID-19 patients and is under review. At this point in time, the department is still adhering to this guidelines and will continue to do so until there is a guarantee that COVID-19 infection is no longer a threat to patients and staffs.

VI. Impact of Covid-19 on Diagnostic Radiology and Nuclear Medicine Medical Physics

Thirteen hospital were under Hamad Medical Corporation (HMC) umbrella, and as the COVID-19 crises started two additional hospitals were added to coup with the high number of COVID-19 patients. At the beginning of the COVID-19 pandemic, Qatar government decided to reduce the number of staff working from office to 20% and the rest had to work from home using online remote access. Most of the work was performed from home, and only urgent activities that required physical presence were performed in the hospitals.

The medical physics team played a critical role since the beginning of the pandemic in ensuring that HMC staff are working in a safe environment while following protocols to prevent the spread of the virus to patients and their fellow staff across HMC. The following briefly describes the activities related to all aspects of Medical Physics, Health Physics and Radiation Safety services offered in all Radiology and Nuclear Medicine Departments at HMC during the COVID-19 pandemic. These activities cover quality control (QC) measurements in new (acceptance

testing) and existing (routing QC) radiological equipment, workplace monitoring, personal dosimetry (TLD), radioactive waste management, shielding surveys of x-ray facilities and QC testing of lead aprons.

Personal Dosimetry

For personal dosimetry, personnel monitoring is carried out using thermoluminescence dosimeter (TLD) badges to cover about 1400 radiation workers in HMC hospitals. Though the normal monitoring period is two months, due to the pandemic, it was decided to extend the use of the same TLD badges for four months (March-June) to avoid any possible spread of viruses between staff from a potentially contaminated TLD badge. In July of 2020, all the TLD badges were replaced to start the new monitoring cycle. Replacement and reading of TLD badges were made with extreme caution to ensure that any potentially contaminated badges would not be a medium of virus spread.

Medical Physicists took all necessary precautions (using masks, gloves and alcohol sanitizers) in the collection of the old and delivery the new TLD badges to avoid potential contamination at both ends (TLD end users from the new TLD badges, and the monitoring service staff from the used TLD badges). Care to avoid contamination was taken during opening of the TLD badges and reading of the TLD cards. All used holders were stored for at least one week before reusing them and the workers were supplied with new holders.

Diagnostic radiology

Medical Physicists performed all essential QC tests for all x-ray units (CT scanners, fluoroscopy, mammography, general, mobile and dental X-ray units). Apart from routine QC testing in units that was past due and could not be postponed, acceptance QC tests had to be performed in all new radiological equipment delivered in HMC hospitals during the pandemic, some of which have been ordered due to pandemic and therefore had to be set in service as soon as possible. For the new equipment, several Medical Physicists had to come to the hospitals to carry out specified task and submit QC report. During the COVID-19 period, Medical Physicists had to perform acceptance QC tests for 3 CT scanners, 7 mobile X-ray, 1 dental CBCT, 2 General X-ray, 2 C-arm, 1 mini C-arm and 3 fluoroscopic units which were all used to equip COVID-19 designated HMC hospitals.

Moreover, working from home provided an ample time and opportunity for the Medical Physicist team assigned to prepare the new QC User Manual and related electronic QC forms, to progress and finalize their task. The QC User Manual is a document that describes in brief the basic methodology for performing all routine QC test performed in all radiological equipment using ionizing radiation, the quantities measured, the required equipment and the remedial levels. The new electronic QC forms (eQC forms) were re-designed from scratch (using Microsoft Excel) to be in line with the QC User Manual and it is expected to completely replace the old forms by the end of 2020.

Routine safety assessment and workplace monitoring of existing radiation facilities were postponed, except for those new facilities such as those that were opened to accommodate COVID-19 patients. Two members of staff were assigned for QC testing of lead aprons (total of 2000 lead aprons in HMC). The task was carried out in isolated X-ray room with extra care to protect the staff collecting and testing the lead aprons.

Nuclear Medicine

During the COVID-19 pandemic, the medical physicists maintained all its normal services for the Nuclear Medicine departments, including the Nuclear Medicine equipment operating in Hamad General Hospital (HGH), as well as the PET/CT in NCCCR. Medical Physics services include a full range of QC tests performed to provide full evaluation of equipment performance, in order to ensure its optimal operation. The service covers PET/CT, SPECT/CT, SPECT, gamma cameras, as well as, dose calibrators, multi-channel analyzers (MCAs), etc.

Moreover, the medical physicists assigned to nuclear medicine, drafted a new QC Manual (based on NEMA and IAEA guidelines) in order to set local Quality Control testing norms/references.

The radioactive waste management program in the Nuclear Medicine departments and the PET CT facility was continuously performed as planned with extra care to protect the staff collecting and storing the waste packages.

Training and licensing of radiation workers

In line with HMC actions to deal with the current COVID-19 situation, it was agreed with the Ministry of Municipality and Environment (the national regulator), to extend the validity of the Radiation Worker License (expired or due for renewal) automatically for 6 months, starting 1 April 2020, to enable HMC staff to continue practicing as usual without renewal.

In August of 2020, as the pandemic situation began to subside and stabilize, and the government started to ease gathering restrictions, the radiation protection training courses (which is a legal requirement for radiation workers in Qatar to renew their licenses) resumed in HMC. These courses were conducted following the current government guidelines on educational gatherings (organized entry by checking temperature, provision of hand sanitizers and wearing of face masks in addition to physical distancing).

Research and Publications

Working from home also gave Medical Physicists an opportunity to perform several activities related to research and publications. Given the fact that many of the normal activities were postponed or canceled, medical physicists had an ample time to revisit previous QC reports, which gave them chance to gather all data in an excel file for comprehensive analysis and for future use. Furthermore, previously started projects prior to the pandemic were finalized, amidst pandemic. The Medical Physicists published eight papers in peer-reviewed international journals [8-15] and participated in five virtual meetings and conferences. In addition, a book was written titled "Quality Control Procedures for diagnostic X-ray equipment" that will be published soon by HMC [16] and also our Medical Physicist contributed a chapter in recently published book on "Medical Physics during the COVID-19 Pandemic: Global Perspectives in clinical practice, education, and research" [17].

VII. Conclusion

Qatar Medical Physics Society (QaMPS) started in 2009 as a small group of medical physicists in HMC, with the mission to advance medical physics practice in Qatar and to promote and support the medical physics profession. QaMPS is one of the founding members of the Middle East Federation of Organization of Medical Physics (MEFOMP). The number of Medical physicists grew from 9 in 2009 to 38 in 2021. The number of Medical Physicists per million is about 13. The average number of Linacs, CT and Nuclear Medicine units are 1.9, 22.2 and 4.4 units per million population, respectively.

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