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.

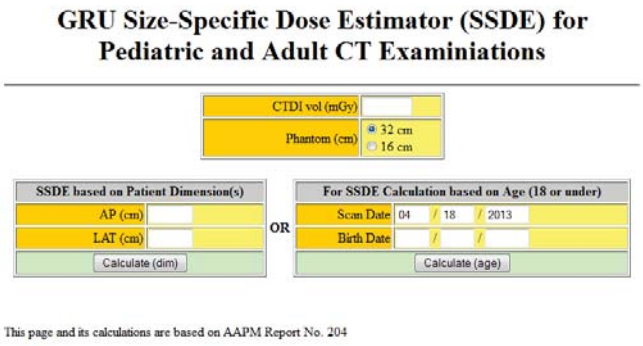

Fig. 1 SSDE Input Screen

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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