MATLAB-based software for Size-Specific Dose Estimation (SSDE) in Computed Tomography Examinations

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ABSTRACT

Primary and widely in use Computed Tomography (CT) dose descriptor is a volumetric CT Dose Index (CTDIv) that is usually measured by a pencil ionization chamber with active length of 100mm and polymethyl methacrylate (PMMA) phantom. CTDIv depends on scan parameters such as mAs, kV, collimation, tube rotation time but is independent of patient's size and shape. For the purpose of a good estimation of dose received by the patients, American Association of Physicists in Medicine (AAPM) published the conversion factors for both 16 and 32cm (head and body phantoms respectively); through this, users can extract conversion factors according to lateral (LAT) and/or anterior-posterior (AP) sizes and calculate real CTDIv. Since this procedure is time consuming, we designed MATLAB-based software to reduce such calculations. To design the software, GUI toolbar of MATLAB software was used. To test the software, scan parameters of two patients for head and pelvis scan were read from PACS and lateral (LAT) and anterior-posterior (AP) sizes were measured. Finally, SSDEs were calculated for two patients by the software. The software can be measured based on AP and/or LAT measures and/or in special cases (under the age of 18) through patients' age.

Keywords: SSDE; CTDIv; Graphical User Interface (GUI); MATLAB

INTRODUCTION

Doses from Computed Tomography (CT) examinations contribute main portion of artificial sources of ionization radiation in the communities. About 68 percent of cumulative dose in the UK and about 67 percent in the US are from CT examinations. [1, 2] So in the last decay has been more attention on CT dosimetry. There are various CT dosimetry metrics that could describe doses from CT procedures. Primary and main of those dose descriptors is computed tomography dose index (CTDI) that could measure in polymethyl methacrylate (PMMA) standard phantoms. [3, 4] New CT scanners are able to display volume CT dose index (CTDIv) on the scanner's console or in dose report [5]. The displayed value on the device's console, reports CTDI, regardless of the patient's shape and size and based on standard phantom [6, 7]. This problem causes concerns, particularly in very fat or slim patients for whom the patient size is different from the size of standard dosimeter phantoms (16 and 32 cm phantoms for head and body respectively) [8]. For correct estimation of dose transmitted to the patients during CT exams, those differences should be considered. Considering those differences will be possible by applying patient size correction factor. AAPM report no.204, "Size-Specific Dose Estimation (SSDE) in Pediatric and Adult Body CT Examinations", addresses this matter [6, 9]. Size-specific dose estimation method in this report is based on measuring anterior-posterior (AP) and/or lateral (LAT) views. Dose estimation is also possible with regard to effective diameter of the patient [7]. The effective diameter can be derived from equation 1. Equation1: Effective diameter=$\sqrt{AP \times LAT}$.There are several tables for determining the correction factor with regard to effective diameter and values of AP and LAT views. It is manifested in this report that the user (physicist or radiology technologist) should extract

intended correction factor referring to them and find out the real dose through several estimations, which is a time consuming process. Therefore, the purpose of this research was to design estimation software based on MATLAB software applicable on different kinds of windows operating systems for the purpose of facilitating those estimations.

MATERIALS AND METHODS
Graphical User Interface (GUI)

Graphical Interface has been used in different sciences to achieve special goals [10, 11]. GUI allows the user to design and use a variety of keys and icons to achieve those special goals. GUI output can be in various kinds of data such as visual data, converted files, extracted files and/or metadata [8, 12]. A successful GUI not only facilitates pre preparation operations, but also allows the user thereafter to display results altogether [10]. We used GUI toolbar of MATLAB software which is user friendly and allows user to easily extract real CTDIv.

Run on windows operating system

After designing user interface and applying orders in MATLAB software, in order to create a file format readable by windows operating system (.exe) and also to execute needed complier, mbuild-setup order was used. Before software run, a special compiler for execution of this file must be installed on windows operating system [6, 13]. This compiler exists in matlab\instal\toolbox\compiler\deploy\win32 under the name of MCRInstaller. This compiler is also available freely for different kinds of operating systems at: http://www.mathworks.com/products/compiler/mcr/

After the installation of MCRInstaller, there is no more need to run MATLAB software in order to conduct estimations [13].

Conversion factors

AAPM report no.204 gives tables of conversion factors based on AP and LAT or (AP+LAT) size and/or effective diameter of patient for both 16 and 32cm head and body phantoms respectively. [6, 7]. If AP and/or LAT size of the patient was unavailable, the user can use the patient age and determine the effective diameter [7].

RESULTS (Testing the software)

In order to test the software, scan parameters of two patients in head and pelvis scan were recorded and images were saved in DICOM format from PACS system and SSDE was estimated by the software.

Scan parameters (kV, mAs, total collimation, and pitch number), dose descriptors (CTDI$_v$), conversion factors and SSDE are shown in table 1. Figure 1 shows LAT and AP sizes of patients.

Table 1. Scan parameters, conversion factor and SSDE for two patients

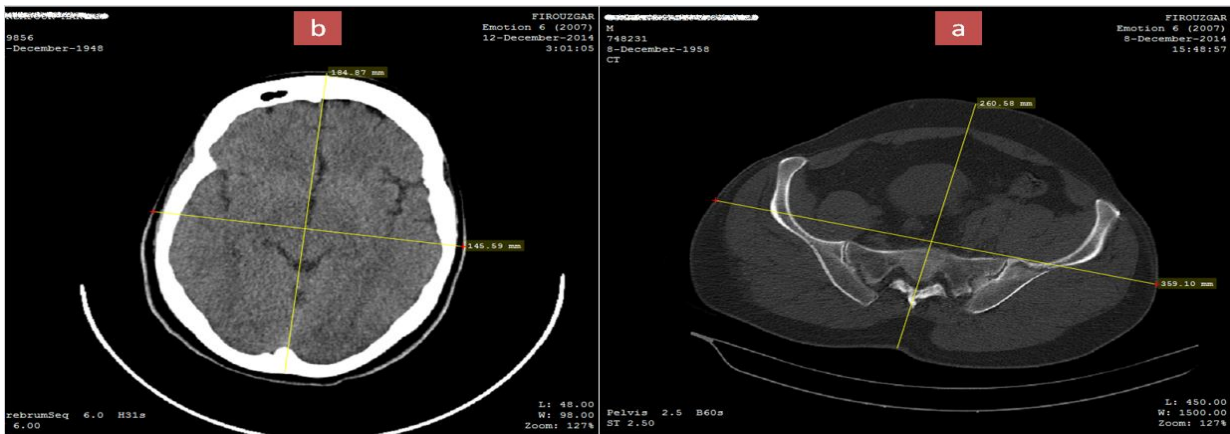| Scan (Sex- Age)↓	kVp	mAs	CTDI$_V$ (mGy)	Effective Diameter (cm)	Conversion Factor	SSDE* (mGy)
Pelvis (F-52)	110	120	8.6	$\sqrt{26.0 \times 35.9} = 30.8$	1.23	10.5
Head (M-66)	110	107	22.9	$\sqrt{18.5 \times 14.4} = 16.3$	1.01	23.2

* According to software results

Figure 1. LAT and AP sizes for two patients undergoing a) pelvis and b) head CT scan

DISCUSSION

In order to design dose estimation software with regard to patient's size, MATLAB-based GUI toolbar was used. The main goal for designing this software was to facilitate estimation of Size-Specific Dose Estimation (SSDE). After installing MCRInstaller, the software can be easily run on windows operating system. The software has also the ability to save data for each patient in a PDF file format. The software can do the estimation based on AP and/or LAT sizes and/or in special cases (under the age of 18) based on the patient age. It should be considered that due to differences in the size of patients in the same age, only if AP and/or LAT sizes were unavailable for a patient we can use effective diameter estimation based on the patient age. Figure 2 shows a view of the software.

CONCLUSION

This study and other reports [6, 7, 14] show that SSDE is a simple and useful method to achieve patient-specific CT dose and patient risk through effective dose during a CT exam. In this study differences between $CTDI_v$ and SSDE in head scan wasn't significant (about 1%), but in pelvis scan it was significant (about 20%).

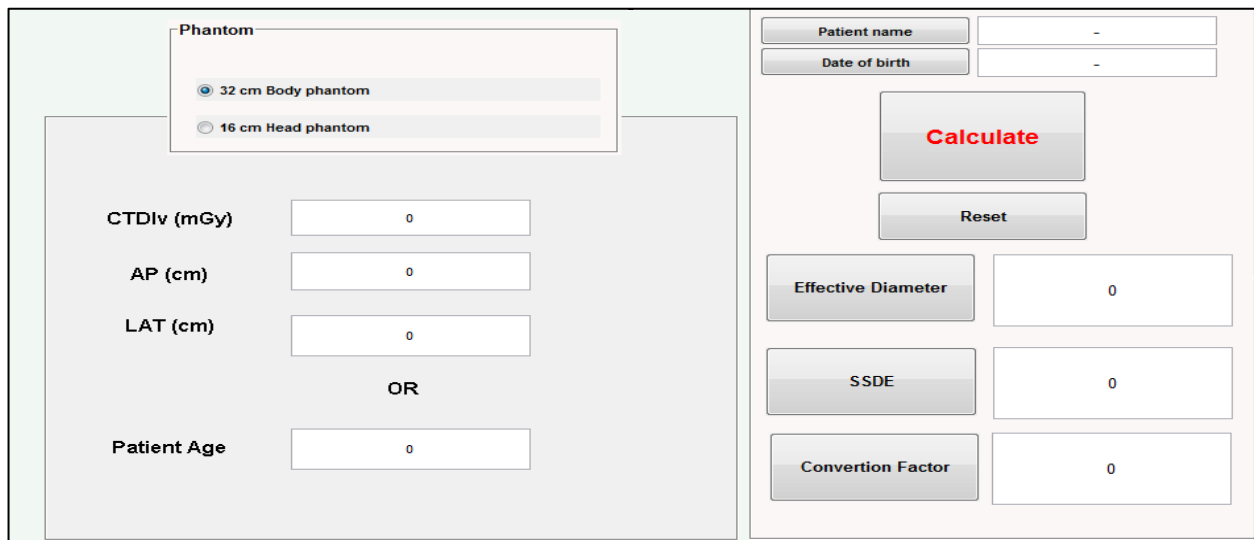*"The authors declare no conflict of interest"*

Figure 2. Size-Specific Dose Estimation (SSDE) software

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