DOSE CONVERSION COEFFICIENTS FOR PEDIATRIC CT PROCEDURES BASED ON SPECIFIC SIZES: OPTIMIZING RADIATION PROTECTION OF SAUDI CHILDREN

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INTRODUCTION

This study was undertaken in 3 large medical centers in Saudi Arabia. Saudi children undergoing computed tomography (CT) procedures vary in sizes. The dose descriptor of CT procedures is commonly expressed in CTDI vol because it is independent of patient size. However, some systems express them in CTDI w. The AAPM Report No. 204 "Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations" concludes that doses vary with patient sizes(1). Hence dose to patients should be optimized and dose reduction techniques should be introduced(2) to different sizes of children.

OBJECTIVES

The aim of this study is to estimate the effective dose of pediatric patients undergoing chest and abdomen CT procedures for different patient sizes. It is also aimed to determine the normalized dose conversion coefficients for Saudi Children of age group 0, 1 and 5 years old.

METHODS

Records of the weight and height of 321 pediatric patients who had chest and abdomen CT examinations were retrieved. The patients were grouped into age groups of 0 (neonates 1 day to 5 months) 1 (6 months to less 2 years) and 5 (2 to 5 years). The equivalent cylindrical diameter (ECD) was determined to estimate the patient diameter. The calculation of ECD used the relationship $ECD = 2[(w/\pi*h)]^{0.5}$ where ECD is the equivalent cylindrical diameter in cm, w is the weight in grams and h is the height in cm(3,4,5). The obtained ECD was compared with the standard pediatric diameters of the National Radiological Protection Board (NRPB).

In the study, a GE 16 slice CT imaging system was used. The data on peak kilovoltage (kVp), tube current (mA), rotation time, slice thickness, pitch, total scan time and CTDI vol values were retrieved. In cases where the CTDIw values were recorded, the CTDI vol values were calculated. The CTDI values considered in this study were the values displayed on the monitor.

The effective doses due to CT were estimated using the CT Expo v1.7 dose calculator program. The normalized dose conversion coefficient values in mSv/mGy for chest and abdomen procedures were determined by dividing the effective dose by the CTDIvol for different ECD. A graph of the dose conversion coefficient with ECD was generated and a the curve fitting equation was generated.

RESULTS AND DISCUSSION

Figure 1 shows the calculated equivalent cylindrical diameter for age groups 0, 1 and 5 and the NRPB standard diameter for the same age group.

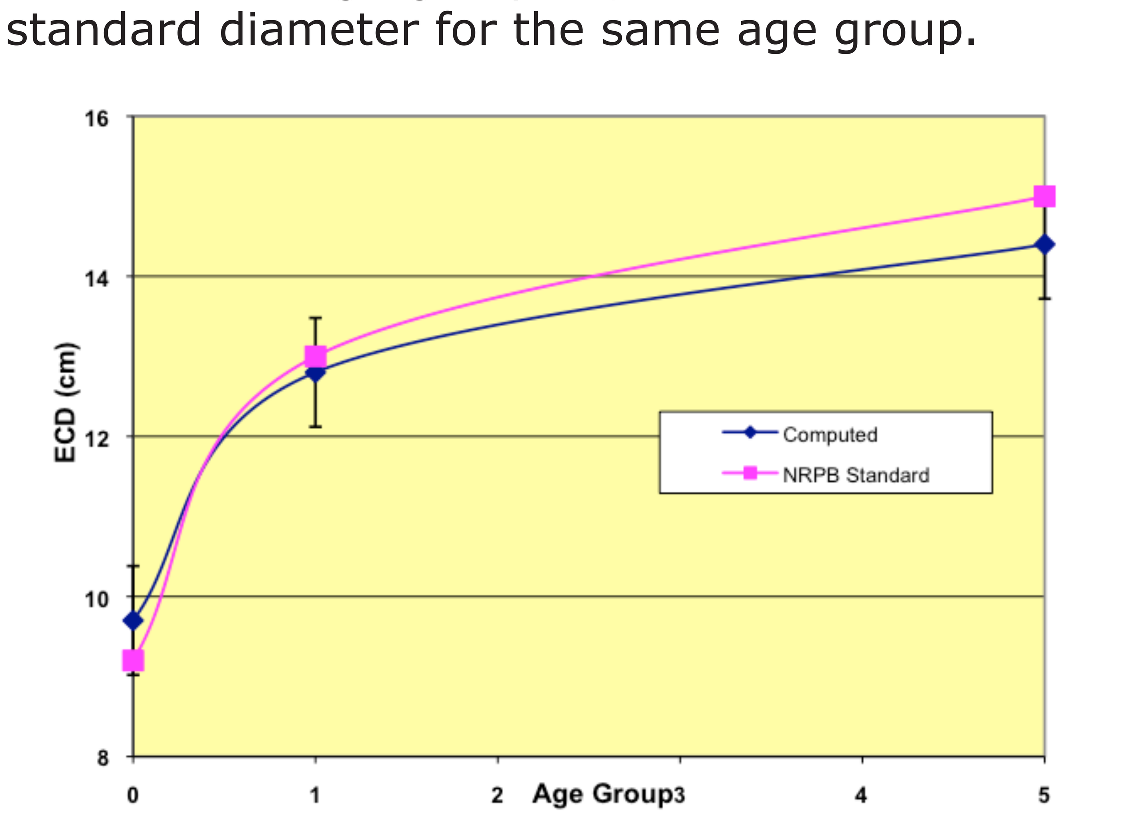

FIGURE 1. Computed patient ECD and the NRPB standard ECD for age groups 0, 1 and 5. The Error bars indicate the standard deviations.

The estimated ECD from the obtained patient data for the age groups 0, 1 and 5 (Figure 1) is in good agreement with the NRPB standard sizes. Correction factors using standard phantoms can therefore be used.

A total of 295 pediatric patients were included in the dose calculation. Table 1 shows the distribution of patients. The age group 5 had the most number of patients (70%) for chest while for the abdomen procedure, age group 1 had the most number of patients (66%).

TABLE 1. Distribution of patients per age group for chest and abdomen procedures.

Age Group	Chest	Abdomen
0	32	22
1	15	92
5	109	25
Total	*156*	*139*

The exposure parameters for chest and abdomen procedures are shown in Table 2. There is a wide variation in the tube current (mA) used for patients in the 3 age groups for both chest and abdomen and the kVp used for chest is the same as that for abdomen. The rotation time for chest was either 0.5 or 1 sec only while for abdomen, it varied from 1.2 to a maximum of 2.5 sec.

TABLE 2. The peak kilovoltage (kVp), average mA and rotation time (sec) with the maximum and minimum values for chest and abdomen procedures.

Parameter	Chest	Abdomen
kVp	100/120	100/120
mA	60.7 (35,250)	81.3 (70, 301)
Rotation (sec)	0.5/1	1.4 (1.2, 2.5)

Pooling all data for each age group, the calculated mean effective doses for chest are the same for the 3 age groups (2.3 mSv) as shown in Figure 2. The chest mean effective dose for neonates is almost the same as the dose for the 5 year age group who had undergone abdomen procedure (2.5 mSv). This is due to the use of 250 mA for neonates which is almost the same mA used for abdomen in age group 5.

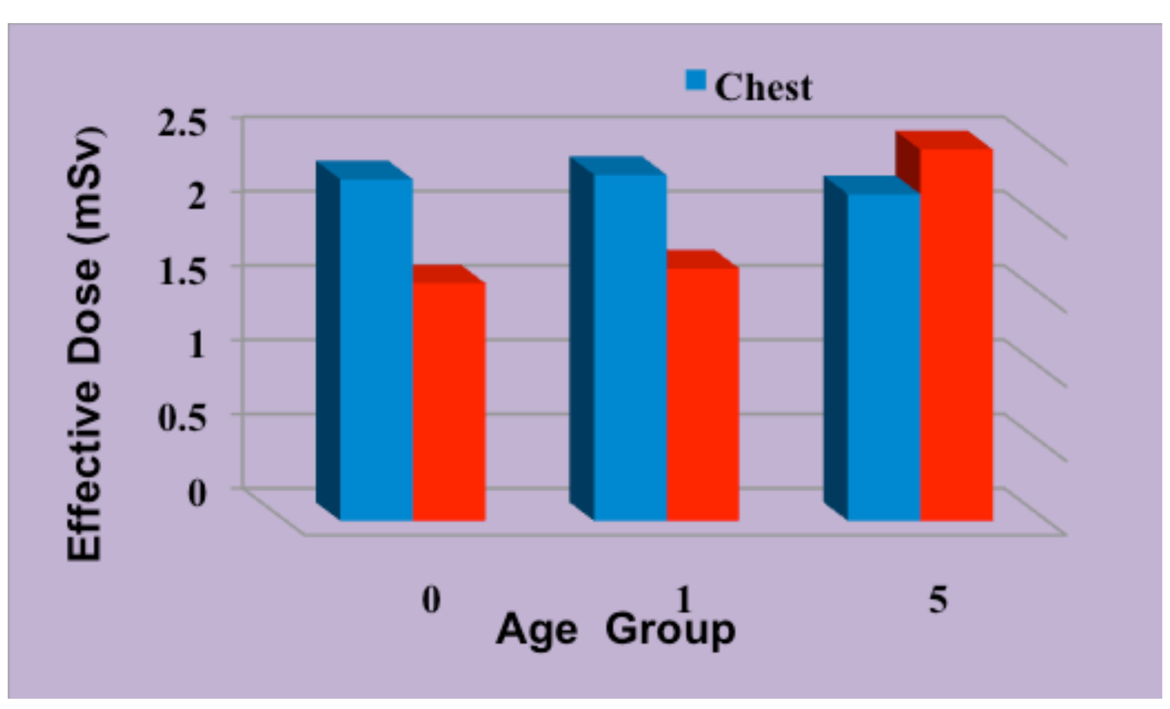

FIGURE 2. Graph of the calculated mean effective (mSv) for patients in age groups 0,1 and 5.

In the calculation of the conversion coefficients, the conversion coefficient for abdomen procedure gave values in the range of 0.45 to 0.47 mSv/mGy with a mean value of 0.46 mSv/mGy for the 3 age groups. The conversion coefficient for chest procedure varied for different ECD values (Figure 3). The obtained dose conversion coefficients were higher than the values in the AAPM Report No. 204 by about 5 to 18%. The steep values of the conversion coefficient for ECD of 8 and 9.7 cm (age group 1) are due to the high mA resulting to a high mean effective dose. The dose conversion coefficient can be determined using the curve fitting equation of the graph.

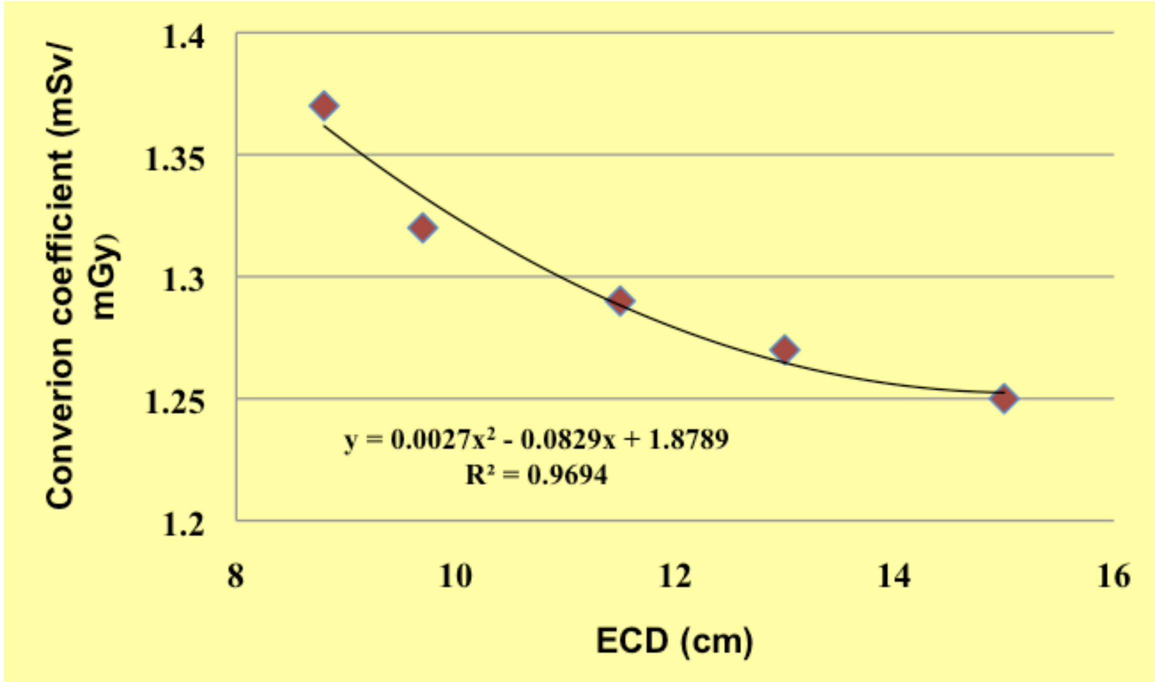

FIGURE 3. Graph of the conversion coefficient against the equivalent cylindrical diameter (ECD) for chest procedure showing the curve fitting second degree polynomial equation.

CONCLUSION

The estimated ECD values for saudi children in age groups 0, 1, and 5 are in good agreement with the NRPB standard sizes. Since in some centers, body mass index and the weight are available, an excel based program can be used using these data to estimate the ECD. The study provides a data base for the effective dose for chest and abdomen procedures performed on pediatric patients in age groups 0, 1 and 5 years old. There are wide variations in the exposure factors for chest CT for the 3 age groups and therefore investigation should be made on the techniques used by different technologists. The wide variation in dose can be attributed to the difference in clinical practice and non-harmonization of protocols(6). Protocols should be standardized and all technologists should be informed on any change in the protocols. Age groups 0 and 1 obtained almost the same effective dose as that of age group 5 for chest procedure. There is a need to lower the tube current for chest CT of neonates. Lowering the tube current to 25 - 40 for chest procedure can make further reduction without significant difference in the image quality. There is a need to provide training to technologists and radiologists on the nature and optimization of doses (CTDIw or CTDI vol) for dose management addressing the doses for neonates. Protocols for these age groups should be reviewed for dose reduction. There is a need to provide data on phantom dose measurements and compare them with the doses obtained using the current protocols for dose reduction and image quality(7).

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