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DOSE ASSESSMENT IN PATIENTS UNDERGOING LUNG EXAMINATIONS BY COMPUTED TOMOGRAPHY

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ABSTRACT

In the last fifteen years, the use of computed tomography (CT) has increased alongside other radiology technologies. Its contribution has already achieved 34% in terms of doses undergone by patients. Radiation protection of patients submitted to CT examinations is based on the knowledge of internationally defined dosimetric quantities as the CT air kerma-length product ($P_{K, L}$) and weighted CT air kerma index (C_w). In Brazil, those dosimetric quantities are not routinely used and the optimization criteria are based only upon the MSAD - the average dose in multislices. In this work, the dosimetric quantities $P_{K, L}$ and C_w were assessed by the CT Expo program for seven protocols used daily for lung examinations in adults with the use of Siemens and Philips scanners in Belo Horizonte. Results showed that $P_{K, L}$ values varied from 163 to 558 mGy.cm and the C_w from 9.6 to 17.5 mGy. All results were found to be lower than the reference values internationally recommended by ICRP 87 and the European Community 16262 (30 mGy and 650 mGy.cm). The large dose ranges suggest that optimization of patient dose reduction is still possible without losses in the image quality and new reference dose levels could be recommended after a large survey to be carried out in the region.

1. INTRODUCTION

Computerized tomography tests CT have increased dramatically in the last 15 years in relation to the total radiodiagnostic exam, increasing the demand from 2 to 5% on average in the world.
It is known that within this small percentage, the value of the average dose in the population is 34%, accounting for the increased of the dose in patients [1]. A tomography chest exam may result in doses 400 times higher than a conventional X-ray exam. According to epidemiological data, the doses absorbed by tissues owing to exams in CT apparatus can increase the probability of incidence of cancer. [2]

In some European countries and North America the culture of protection to patients is being achieved through the creation of an adequate legislation for the verification of doses in patients submitted to radiodiagnostic exams according to measures of magnitudes and parameters leading to the knowledge of those, aiming at the demonstration of the optimization [3,4]. The Brazilian legislation has no records of doses in patients. It uses as criteria of optimization, only the values of the average dose in multiple slices (MSAD – Multi Slice Average Dose) in an average adult as a parameter of quality control of tomographers [5]. The Protection of the patient has been sought by means of estimation of dosimetric magnitudes: CT air kerma-length product ($P_{K,L}$), volumetric CT air kerma index (C_{vol}) and weighed CT air kerma index (C_w). The DRL- Diagnostic Reference Level, is a parameter created aiming at minimising the doses and dose variation at a minimum cost to the radiology departments [6,7], as defined by the International Atomic Energy Agency (IAEA) as ‘orientation levels’ [8].

In this work the dosimetry quantity $P_{K,L}$, C_{vol} e C_w were estimated for patients submitted to chest exams in computed tomography. These doses will contribute to the establishment of the DRL in Belo Horizonte.

2. MATERIALS AND METHODS

The software CT Expo v.1.7.1, 2010 was used to calculate the dosimetric quantity in TC. This program is an excel spreadsheet well designed by German researchers and offers a higher complexity of data in relation to other softwares, such as: the ability to calculate doses for different ages, genders and types of scanners.
The program has four different mathematical phantoms: adult (male and female), children and newborns (Fig. 1), besides having resources for the comparison of the results of the current research with those produced by the German’s scanners [9].

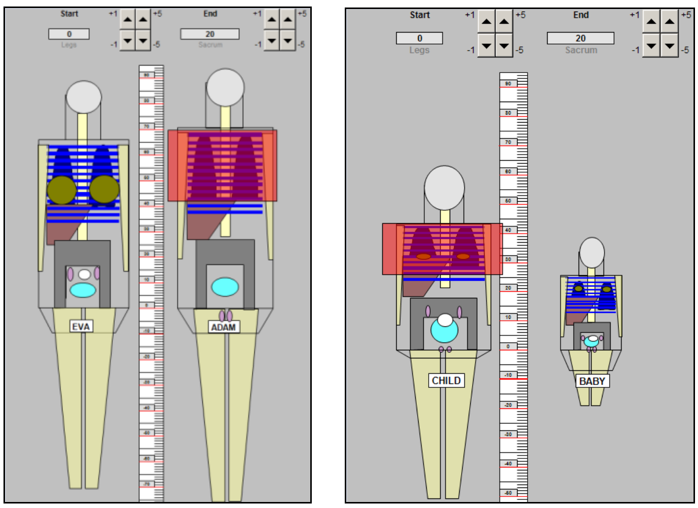

Figure 1 Mathematical phantoms: adult (left) child (right)

The CT Expo is subdivided into three distinct modules such as: calculate, standard and benchmarking. The calculate module (Fig.2) allows for the calculation of the dose for all age groups, and gender of patients. The module standard offers pre-defined patterns of dose calculations for tomography exams (only for adults), and has comparison techniques matching the German's scanners. The module benchmarking permits a verification of protocols of reference for the whole set of 14 CT standard exam that were analyzed during the German research on CT exam. In this module it is possible to use two spreadsheets: MSCT for multislice and SSCT for a single slice, given that, in accordance with the type of equipment, the program itself alerts the user to choose either spreadsheet. It is possible to evaluate the values of doses of an exam in a certain hospital and compare them to doses obtained in the German tests.

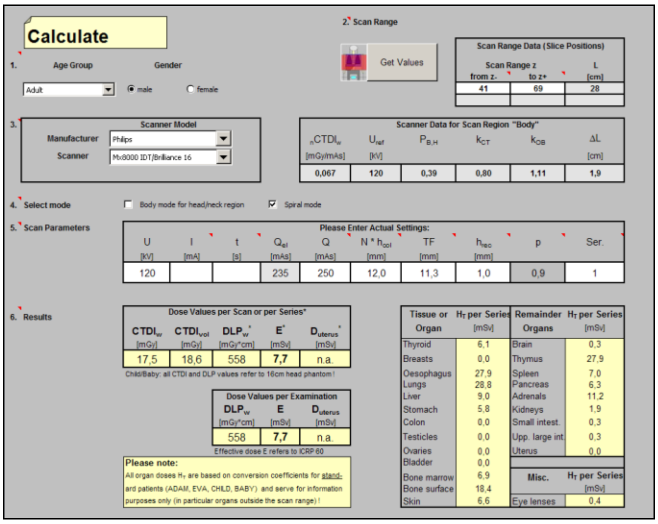

Figure 2 Calculate Module

The program works by filing the gaps which regard the manufacturer, model of equipment, gender, voltage, current, time, collimation, slice thickness, table feed, scan range, and number of series. The calculations made are based on the Monte Carlo method and adopt the norm ICRP 60- International Commission in Radiological Protection as a reference [10].

The data collected from the seven protocols were inserted into the programs (module calculate) and their values were registered. The scan range the lungs of the adult male mathematical phantom was standardized to 28 cm for all protocols.

The dosimetric magnitudes of each protocol calculated by the program were compared with the ones established by the norm EURATOM 16262 e ICRP 87 [2, 6].

3. RESULTS AND DISCUSSION

The seven thorax protocols used in this study are represented in Table 1:

Table 1 Thorax protocol from seven individual scanners

Hospital	A	B	C	D	E	F	G
Tube voltage (kV)	130	120	130	130	120	120	130
Tube current (mA)	113	240	70	113	250	180	80
Time (s)	0.8	0.5	1	0.8	0.5	1	1
Thickness (mm)	5	1	10	5	1	2.5	8
Speed table (mm/rot)	7.5	89.6	30	7.5	11.3	10	12
Pitch (mAs/slice)	1.5	1.4	1,5	1.5	0.94	2	1.5
Colimation (mm)	1 x 5	64 x 1	2 x 5	1 x 5	16 x 0.75	2 x 2.5	1 x 8

The EURATOM and ICRP 87 were applied as the criteria used as the basis for the analysis of the dose in adult patients so that this criterion established could be compared with the doses in the results found in the programs. This principle aims at establishing a parameter for these doses, by trying to reduce their application in the patient without altering the quality of the exam. However, the dose criteria established for chest exams, taking into consideration the two norms as a parameter is: 650mGy. cm for $P_{K,L}$ and 30mGy for C_w [5].

Table 2 shows the doses calculated by CT Expo with reference to every hospital:

Table 2 Dose obtained through the protocol of each hospital

Hospital	$P_{K,L}$ (mGy.cm)	Cw (mGy)
A	267	13.6
B	321	11.0
C	193	9.6
D	267	13.6
E	558	17.5
F	163	10.7
G	243	12.0

The maximum comparative percentage variation of the doses was: 71% for $P_{K,L}$ and 45% for C_w. The greatest percentage variation can be explained by the fact that the $P_{K,L}$ involves two other quantity: C_w and C_{vol}, as shown respectively in the equations 1, 2 and 3. On the other hand, the smaller percentage variation is explained by the fact that the parameters of each scanner are different, given that the measurements and the body phantom PMMA are the same.

$$C_W = \frac{1}{3}\left(C_{PMMA,100,c} + 2C_{PMMA,100,p}\right) \tag{1}$$

where C_w is the weighed CT air kerma index and $C_{PMMA,100}$ values measured at the centre and periphery of a standard CT dosimetry phantom;

$$C_{vol} = \frac{C_W}{p} \tag{2}$$

where, C_{vol} is the volumetric CT air kerma index and p represents the pitch factor (or pitch);

$$P_{K,L} = \sum_j {}_n C_{vol_j} l_j P_{It_j} \tag{3}$$

where $P_{K,L}$ is the CT air kerma-length product; the index j represents each serial or helical scan sequence forming part of the examination, l_j is the distance the patient table moves between or during consecutive scanner rotations and P_{It} is the total tube loading for scan sequence j.

4. CONCLUSION

In all hospitals it was noticed that the dosses were below DRLs established by the norms. The variation in the results occured due to the fact that the scanners and technical information of each protocol are different. The large number of manufacturers allows for the existence of different protocols for the same type of image acquisition with the same diagnostic objective.
The higher dose was noticed at hospital E and the lower of hospital F, this statement was explained by the different values of: current, pitch, collimation, table feed, amongst other parameters of the scanners.

The study of doses in patients is important to promote the knowledge and use of the dosimetric quantity in CT so that the optimization of the procedure and the minimum standardization can be achieved.
The results presented demonstrate that it is possible to estimate the doses and reach accuracy in this values through new essays. With the availability of other protocols it will be possible to attain a higher reliability on the software, even its validation.

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