Evaluation of Radiation Dose in Computed Tomography Standard Beams Using Simulators

Elaine Wirney Martins, Maria da Penha Albuquerque Potiens
Instituto de Pesquisas Energéticas e Nucleares (IPEN / CNEN - SP)
Av. Professor Lineu Prestes 2242
05508-000 São Paulo, SP
ewmartins@ipen.br
mppalbu@ipen.br

Abstract
Computed tomography (CT) is a diagnostic imaging method widely used since its discovery. When CT is compared with conventional radiology, its radiation dose is higher almost always and the absorbed dose to the patient is also higher. The increasing use of CT in children has been verified mainly by reducing the time required to scan - now less than 1 second – eliminating, in most of the time, the use of anesthesia to prevent the child movement during image acquisition . The harmful effects of radiation are more likely to happen in children than in adults because they are in growth stage. Studies have shown that the absorbed doses in pediatric CT examinations ranged between 0.7 mSv and 3.5 mSv and the risk of developing cancer during their lives has been 0.16%. These measurements have been done in phantons which simulate 5 year-old children. In the present study it was used two acrylic simulators developed at the Laboratório de Calibração de Instrumentos (LCI) that belong to the Instituto de Pesquisas Energéticas e Nucleares (IPEN). The objective of this study is to perform measurements in standards radiaton beams for CT using pediatric phantom to determine the CT air kerma indices Ca,100 and C_W (free in air and in phantom) and the air kerma-length product (P_{KL}), using a calibrated pencil ionization chamber. In addition, measurements at the pediatric phantom surface were done to obtain the entrance surface air kerma (Ke).

Key Words: Pediatric phantom, Entrance surface air kerma, absorbed doses in pediatric CT.

1. Introduction

Computed tomography (CT) scan is an imaging method that has as basis the same principles as conventional radiology. It uses X-rays to produce an image with a view to obtaining diagnostic order to evaluate the possibility of developing a disease or even delete it [1]. Unlike conventional radiology, the dose of ionizing radiation used in CT is almost always higher [2].

The largest increases are in the use of CT in pediatric diagnostic category [3,4] scanning and adults, and one can expect this trend to continue in coming years [5-10]. This increasing use of CT in children has been mainly by reducing the time required for the test - now less than 1 second - removing, in most cases, the use of anesthesia to prevent the child from moving during image acquisition [3].

The main objectives of the patient dosimetry in relation to X-rays used in medical imaging is to determine the dosimetric quantities for the creation and use of diagnostic reference levels and risk of stochastic effects. To this goal the work presented here was developed.

2. Materials and Methods

For dosimetry measurements it was used the CT standard radiation qualities were established in a Pantak/Seifert X radiation system, model Isovolt HS 160, Voltage from 100 kVp to 150 kVp. I was used a reference pencil ionization chamber Radcal, RC3CT model, with volume 3 cm^3, calibrated at PTB (Germany) in a pediatric phantom developed by IPEN with the dimension of 10.0 cm X 15.4 cm, as shown in Figure 1, respectively.

To perform the measurements the pediatric phantom was positioned one meter away from the X-ray focus. The pencil ionization chamber for K_e measurements was positioned in the air closed the phantom and to calculate the Cw the camera was positioned in the central cavity of the phantom.

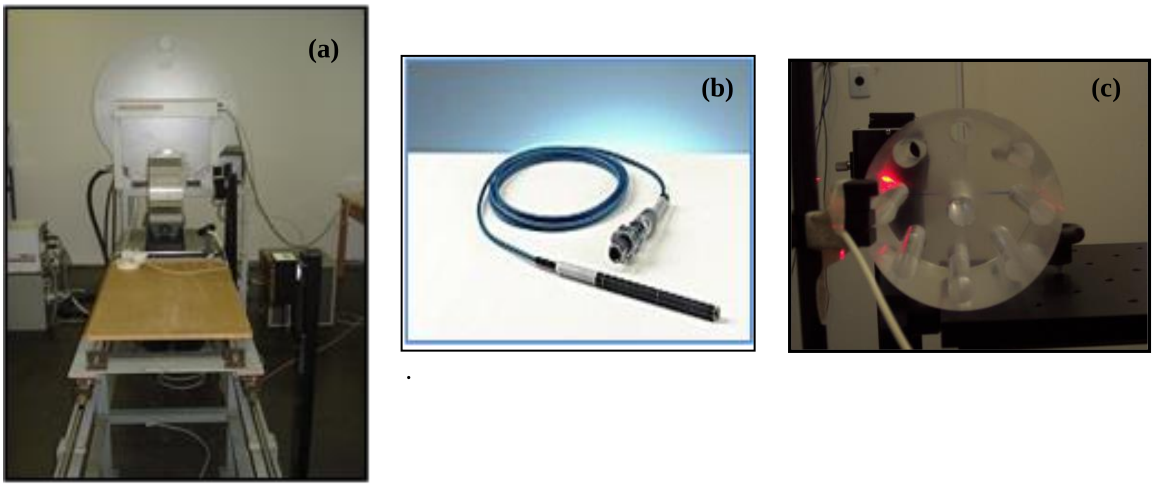

Figure 1: a) ISOVOLT X radiation system (160 kV), b) calibrated pencil ionization chamber; c) pediatric phantom developed by IPEN

3. Results

The obtained results for air kerma rates (K_{air}) and the air kerma length product (P_{KL}) are presented in Table 1. Additionally the entrance surface air kerma (K_e) were determined using the pediatric phantom. The ionization chamber was positioned outside the phantom. The CT air kerma indices Ca,100, CW (free in air and in phantom) and Cvol (derived from CW), were calculated according to TSR457 [11], are in Table 2.

Table 1. Radiation qualities characteristics, air kerma rates (K_{air}), air kerma length product (P_{KL}) and the entrance surface air kerma rates (K_e).

Radiation qualities	Tube Voltage (kV)	Filter	HVL (mmAl)	K_{air} Gy/min	K_e Gy/min	P_{kl}
RQT 8	100	3.2mm Al + 0.3mm Cu	6.90	0.018	0.008	0.18
RQT 9	120	3.5mm Al + 0.35mm Cu	8.40	0.027	0.010	0.27
RQT 10	150	4.2mm Al + 0.35mm Cu	10.1	0.045	0.017	0.45

Table2. CT air kerma indices C_k, C_{PMMA}, C_W (free in air and in pediatric phantom) and C_{vol} (derived from C_W).

Radiation qualities	C_k	C_{PMMA}	$C_{PMMA,P}$	C_W	C_{vol}
RQT 8	0.018	0.023	0.032	0.029	0.2
RQT 9	0.027	0.035	0.048	0.044	0.4
RQT 10	0.045	0.058	0.079	0.072	0.7

4. Discussion and Conclusions

The CT air kerma indices C_k, C_{PMMA}, and C_W (free in air and in the pediatric phantom) and the air kerma-length product (P_{KL}) were determined in this study allowing the possibility of the use of a calibration standard beam for CT measurements in order to establish methods to analyze CT parameters. In addition, measurements at the pediatric phantom surface developed at IPEN were done to obtain the entrance surface air kerma (K_e). More studies will be made in order to complete a quality control programme as close as possible to the used in medical clinics and hospitals.

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