Determination of Specific CT Quantities in Standard Beams using Phantoms

Elaine Wirney Martins and Maria da Penha A. Potiens

***Abstract* — The radiation dose in diagnostic imaging technique using computed tomography (CT) is almost always higher when compared to conventional X ray technique. This is due to the uniformity of the radiation dose applied around the patient generated by rotation of the tube inside the gantry. CT uses X-rays to produce an image with a view to obtaining diagnostic in order to evaluate the possibility of developing a disease or even delete it [1]. For the reliability of the radiation beams the CT scanners must be working properly and under a periodic calibration program. In 2007 the International Atomic Energy Agency (IAEA) published a code of practice recommending procedures for calibration and dosimetry in diagnostic radiology (Technical reports series no. 457) and in 2011 it was published its implementation in order to decrease the uncertainties. The objective of this study is to perform measurements in standards radiaton beams for CT using body and head phantoms to determine the CT air kerma indices $C_{a,100}$ 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 body phantom surface were done to obtain the entrance surface air kerma (K_e).**

***Index Terms* — computed tomography, dosimetry, CT air kerma indices, entrance surface air kerma.**

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E.W. Martins is with the Instituto de Pesquisas Energéticas e Nucleares, Sao Paulo, 05508-000 Brazil (corresponding author to provide phone: +55 11 3133-9652; e-mail: elainewirney@usp.br).

M.P.A. Potiens is with the Instituto de Pesquisas Energéticas e Nucleares, Sao Paulo, 05508-000 Brazil (e-mail: mppalbu@ipen.br).

I. Introduction

After discovering the X-rays, in 1895, made possible the frequent use of ionizing radiation in medicine and it has become a concern due to the damage for health. Although ionizing radiation has advantages for medical treatment compared to invasive methods, it must be certain that the benefit of using this type of exposure radiation will be greater than the associated risks to the patient, in addition to the absorbed dose that needs to be as smallest as possible (ALARA principle - As Low As Reasonably Achievable). With the advent of computed tomography in the mid-1970s its use has rapidly increased [2]. By its nature, CT involves larger radiation doses than in conventional X-ray procedures.

The use of CT can be classified according to the patient population (adult or pediatric) and the purpose of the image (diagnosis in symptomatic patients or screening of asymptomatic patients). About half of the CT diagnoses in adults are body scan, and about a third are scans of the head. The largest increases are in the use of CT in pediatric diagnostic category [3,4] and scanning of adults, and one can expect this trend to continue in the coming years [5-10].

As computed tomography is one of the must applied methods of diagnostic radiology services, this method must have an effective and safe quality control program. Thus, the performance of equipment should always be checked. There is also a need to determine the dosimetric quantities for the creation and use of diagnostic reference levels for benchmarking and risk of stochastic effects.

II. MATERIALS AND METHODS

The reference pencil ionization chamber is from Radcal, RC3CT model, with 3 cm³, is shown in figure 1. The ionization chamber is a kind of dosimeter used in radiology area to determine the absorbed dose in an environment exposed to ionizing radiation and to measure kerma air exposure. Its basic principle is to use a gas in its interior for performing measurements [12-15].

Its operation is the simplest of gas detectors having a central collector electrode and chamber wall defines a cavity filled with a gas. They are built taking into account the collection of ions produced by ionizing radiation in the detector sensitive volume.

Fig. 1: Calibrated pencil ionization chamber

(Color figure available only in the electronic version of this paper.)

The CT standard radiation qualities were established in a Pantak/Seifert, Isovolt HS 160 model X radiation system with a voltage variation from 100 kV to 150kVp (figure 3). This chamber was calibrated at the *Physikalisch-Technische Bundesanstalt* (PTB).

The body and head phantoms used were developed at IPEN and have dimensions of 10 cm X 15.4 cm (figure 2).

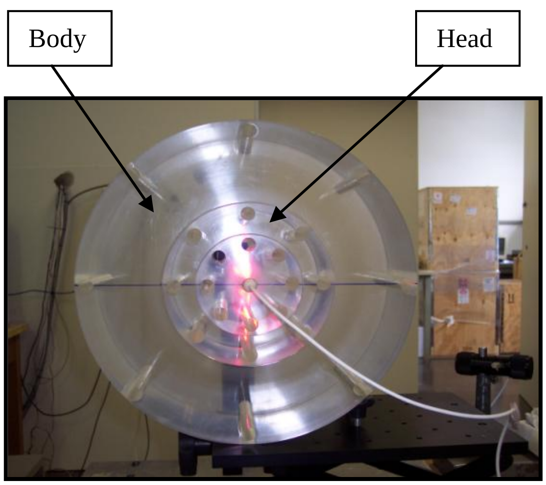

Fig. 2: Body and head phantom developed by IPEN.

(Color figure available only in the electronic version of this paper.)

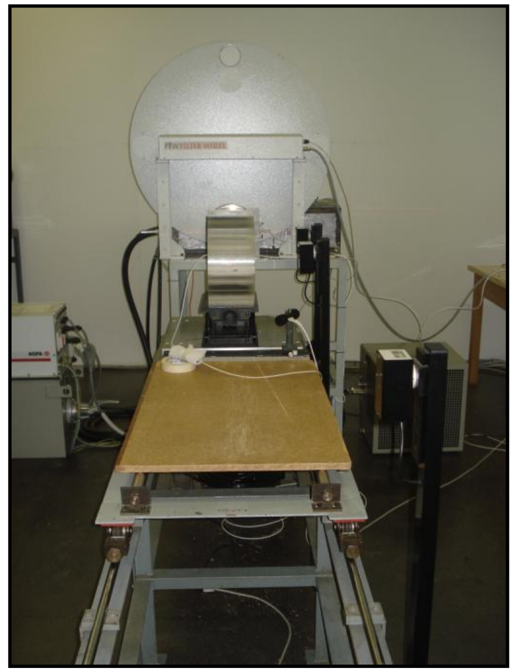

Fig. 3: ISOVOLT X radiation system (160 kV)
(Color figure available only in the electronic version of this paper.)

III. RESULTS AND DISCUSSION

The obtained results for air kerma rates (K_{air}) and the air kerma length product (P_{KL}) are in table 1. Additionally the entrance surface air kerma (K_e) were determined using the body phantom. The ionization chamber was positioned outside the phantom. The CT air kerma indices $C_{a,100}$, C_W (free in air and in phantom) and C_{vol} (derived from C_W) 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) obtained.

Radiation qualities	Tube Voltage (kV)	Filtration	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	0.023	0.18
RQT 9	120	3.5mm Al + 0.3mm Cu	8.40	0.027	0.034	0.27
RQT 10	150	4.2mm Al + 0.35mm Cu	10.1	0.045	0.057	0.45

TABLE 1 CT air kerma indices $C_{a,100}$, C_W (free in air and in phantom) and C_{vol} (derived from C_W).

Radiation qualities	C_k	$C_{PMMA,C}$	$C_{PMMA,P}$	C_w	C_{vol}
RQT 8	0.018	0.024	0.037	0.033	0.3
RQT 9	0.027	0.007	0.056	0.040	0.4
RQT 10	0.045	0.013	0.091	0.065	0.6

IV. Conclusion

The CT air kerma indices $C_{a,100}$ and CW (free in air and in 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 body phantom surface 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.

1) publication in a Transactions or Journal.

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