Applied Radiation and Isotopes 71 (2012) 40–43

Contents lists available at SciVerse ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

Radiation protection in CT pelvis in Fantoma Rando by thermoluminescent dosimetry

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HIGHLIGHTS

► The areas surrounding the study, as is the area of the chest, abdomen and a radiosensitive organ in a study of the pelvis (gonads), we obtained a significant contribution.
► This variation can be attributed to three main factors: the number of cuts, the distance and the density difference.
► Increasing the dose equivalent as critical organ is due to completion of the study of the pelvis associated with having a number of overlapping slices.

ARTICLE INFO

Available online 24 May 2012

Keywords:
Computed tomography
Critical organ
Dosimetry
Thermoluminescent

ABSTRACT

This paper presents results of equivalent dose organ determining to both primary beam and scattered radiation in a computed tomography (CT) procedures. All measurements were carried out to abdomen and critical organ (gonads) area. Selected dosimeters showed a standard deviation of 4.1% below to the reference values established by international guide lines. The equivalent dose in gonads was 14.27 mGy.

1. Introduction

Diagnostic procedures by ionizing radiation sources should be performed using all possible means, to reduce the exposure to the patient, without affecting the image quality it all diagnostic procedures if procedures are carried out according the international guide lines (EURATOM). Computed tomography (CT) is a combination with the science of X-rays with computer technology to produce images more focused and informative than conventional X-rays, such as medical diagnostic imaging method. The CT can explore inside the human body, through multiple projections cerebrospinal axis but this exposure increase significant levels of ionizing radiation to patients. Computed tomography continues to contribute a significant portion, up to 50%, of the collective radiation dose from all radiographic examinations. The radiation doses delivered to certain organs are significant enough to be a matter of concern McLaughlin and Mooney (2004).

In 1982, WHO (Borras et al., 2001). published guide lines for quality assurance in diagnostic radiology, which were translated and published by PAHO in 1984. Five countries, i.e. Argentina, Bolivia, Colombia, Cuba and Mexico received research contracts involving medical physicists and radiologists (Jessen et al., 1999). Within this project different aspects were evaluated as well as pathologies, radiological examinations, the type of devices, etc. Mexico omitted computed tomography and pathology under a specific procedure established by the project evaluation.

Thermoluminescent has been conducted as a good tools for radiation dosimetry and its applications different medical practices to medical physics, radiation protection, personal dosimetry and environmental dosimetry. All these areas have a common objective the absorbed dose determining. In some, the precise evaluation of the dose has direct implications on the health of living beings. (Brenner et al., 2007). CT dosimetry in diagnostic radiology which concerns patient dosimetry and phantom dosimetry as well as occupationally and environmental dosimetry have been a fundamental need in the radiation dosimetry especially in the field of medical physics. In the literature there are some results of CT radiation dosimetry in density: head, abdomen and lumbar spine, setting the average doses in multiple scans for computed tomography study. (Borras et al. 2001). The dose given to patients in tests TC depends on the technique used, the characteristics team (geometry, filtration, detector system, etc.) and the patient's anatomic area which is irradiated.(Salvadó i Artells et al., 2003)

The aim of the present work is to determine CT radiation dose for primary beam and scattered radiation by means of thermoluminescent phenomenon.

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0969-8043/$ - see front matter © 2012 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.apradiso.2012.04.028

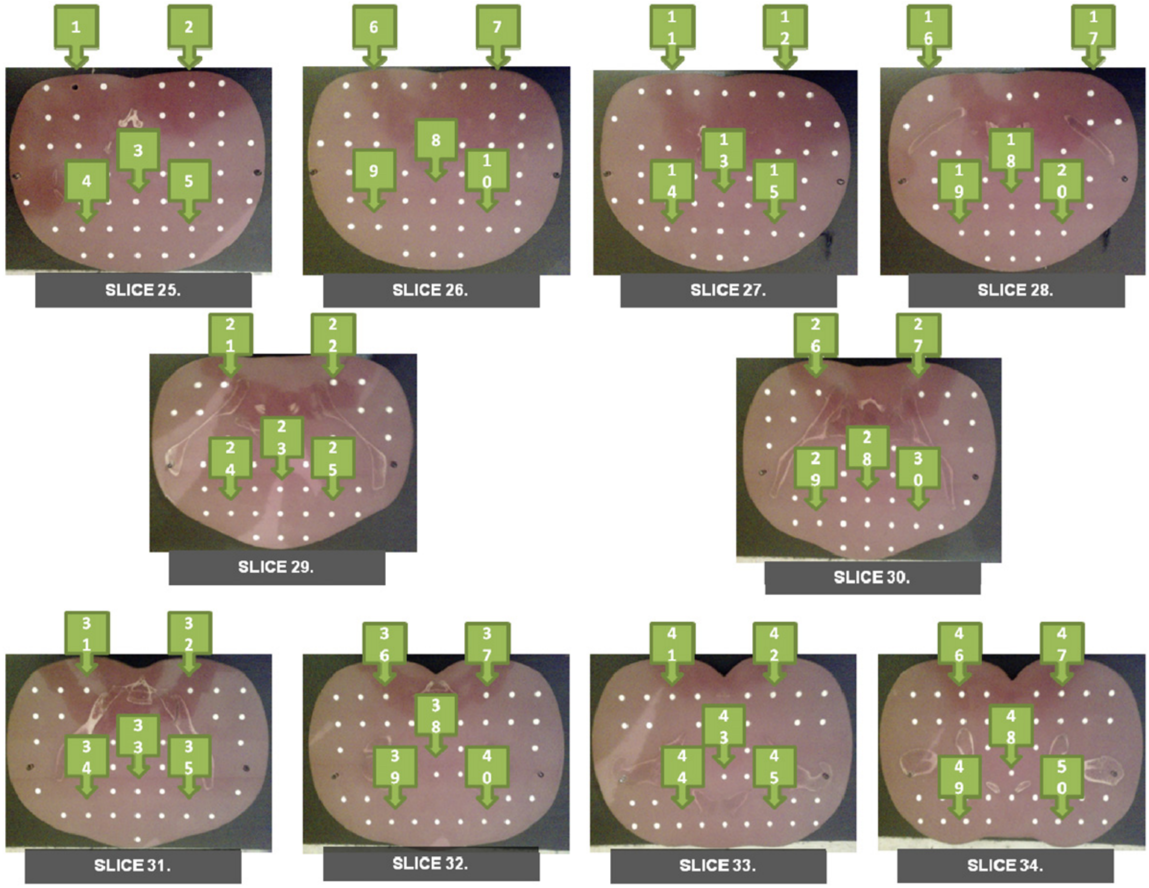

Fig. 1. Distribution of TLDs-100 into the phantom to determine the CTDI.

Fig. 2. Introduction of the Rando phantom to TC.

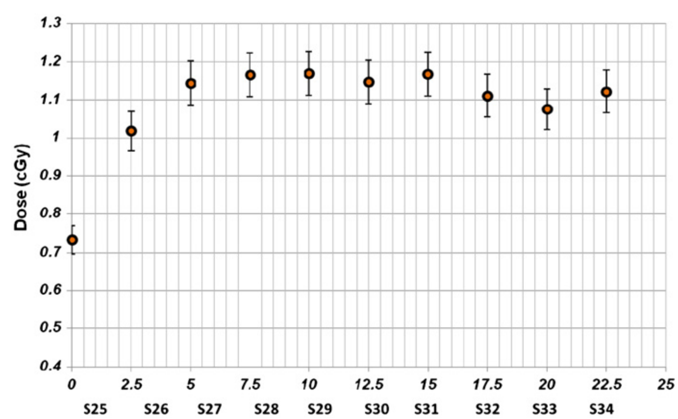

Fig. 3. Tomography dose index.

Table 1
Absorbed dose values of CTDI in study pelvis.

Slice Positioning	Ratio of TLDs Positioning	Average dose per slice (cGy)
S25	0	0.733 ± 0.03
S26	2.5	1.018 ± 0.07
S27	5	1.144 ± 0.05
S28	7.5	1.166 ± 0.04
S29	10	1.170 ± 0.13
S30	12.5	1.147 ± 0.03
S31	15	1.168 ± 0.04
S32	17.5	1.111 ± 0.13
S33	20	1.075 ± 0.02
S34	22.5	1.122 ± 0.07

2. Experimental details

One batch of 160 dosimeters TLD-100 was calibrated, firstly all TLDs were inspected in terms of its size and that were not damaged. For TLDs calibration, TLDs were irradiated with gamma radiation of 60-Co at an absorbed dose of 100 cGy. Reading the deletion process and irradiation is as follows: a thermal erasing process was performed with a PTW Freiburg TLD0 automatic muffle. The TLD-100 broke into the muffle for 1 h at 400 °C, followed by 2 h at 100 °C, then allowed to decrease the temperature of treatment up to room temperature, this process takes 16–18 h. Cobalt irradiation was performed in a 60Co Theratron unit 780 C, using plates 5 (phantom) of solid water to have the electronic balance and the maximum depth ionization source 60Co to the area of location of the dosimeter, which can position 25 dosimeters. The arrangement of solid water plates consists of 3 plates of thickness 2 cm below the plate 5 cm thick which are located above the dosimeters and dosimeters was placed a plate of 0.5 cm (build-up). It was the reading of the dosimeters in two brand Harshaw TL reader 5500 and 3500. It established a series of cycles formed by the deletion process, 60Co irradiation and reading all this for the determination of correction coefficients. Per cycle, reading occurred 2 h after irradiation, the analysis of the calibration process is done in the program of the reader WinRems. In the reading had to set parameters on the software for time–temperature profile.

To determine element correction coefficients (ECC) a small batch was irradiated with gamma radiation and average error of the measured intensity error was determined. This batch of TLDs with the best intensity was used to determine the reader calibration factor (RCF) units μGy/nC. To obtain TL response as a function of absorbed dose, a batch of 60 TLDs was irradiated at different doses ranging from 10 to 200 cGy. One of the priority activities was to obtain the dose rate of the scanner (CTDI), this procedure was determined during the study of the pelvis of a series of contiguous X-ray exposure, direct the study area by using a phantom anthropomorphic (Rando). To determine equivalent dose a Rando phantom was used. 50 TLDs were placed in the phantom distributed into 10 slices that make up the area of pelvis and abdomen. Rando phantom with TLDs inside of this was introduced a supine position into a CT device, as shown in Fig. 1. The irradiation procedure was starting from a position between 25 and 26 slice Rando Fantoma under common parameters according to a adult patient database in the same hospital, as shown in Fig. 2. To organ dose was determined placing 5 TLDs in gonads region with 51 and 52 slices in the middle of the phantom. To determine absorbed dose in pelvis and abdomen, 50 TLDs were placed into 24 and 25 slices of the Rando Phantom. TLDs into each slice scanning procedure was carried, the scanning was started between 24 and 25 slice. There were four radiation and reading in this procedure, TLD readings were carried out in a Harshaw 3500TLD reader.

3. Results

Selected dosimeters showed a standard deviation of 4.1% below the established 5% accepted for dosimetry in diagnostic radiology in their element correction coefficients for a first reading system. The standard deviation of a subset of the lot already calibrated dosimeters was 1.4% for a second reader system.

CT DI value was 1.02 ± 0.05 cGy, this is shown in Fig. 3 and the values are shown in Table 1. The absorbed dose due to primary beam and scattered radiation in the abdomen and gonads showed a variation according to the number of cuts and downstream from the phantom position. During this procedure with 26 cuts was a critical organ absorbed dose of 14.27 ± 1.93 mGy. By increasing the absorbed dose in critical organ measure is due to the termination of the study involved pelvis having a number of cuts thereby establishing a dose amount which consequently has an increase in the absorbed dose; this is shown in Fig. 4.

Reported for the standard effective dose, i.e. whole body dose, whereas the values obtained for our study is for a study area by comparing the values obtained are slightly higher than those in the literature and with it a higher surface absorbed dose as reported in the literature.

Experimental absorbed dose for the primary beam and scattered radiation gave a value of 14.27 ± 1.93 mGy during a CT procedure. This corresponds to 29% more than the average of the values located in the region of effective use of the radiation beam, ie, that radiation useful for the study. Experimental results of absorbed dose determined by TLDs were compared with those reported by literature. As it can be seen in Table 2, the absorbed dose obtained is higher than that reported. Experimental results

Table 2
Comparison of pelvic dose reported by EURATOM (Radiation Protection 118., 2007).

Abdomen average dose absorbed (mGy)	Pelvis average dose absorbed (mGy)	Effective dose reported pelvis and abdomen by EURATOM (mSv)	Gonal dose absorbed (mGy)
2.36 ± 0.05	11.04 ± 0.39	10	14.27 ± 1.93

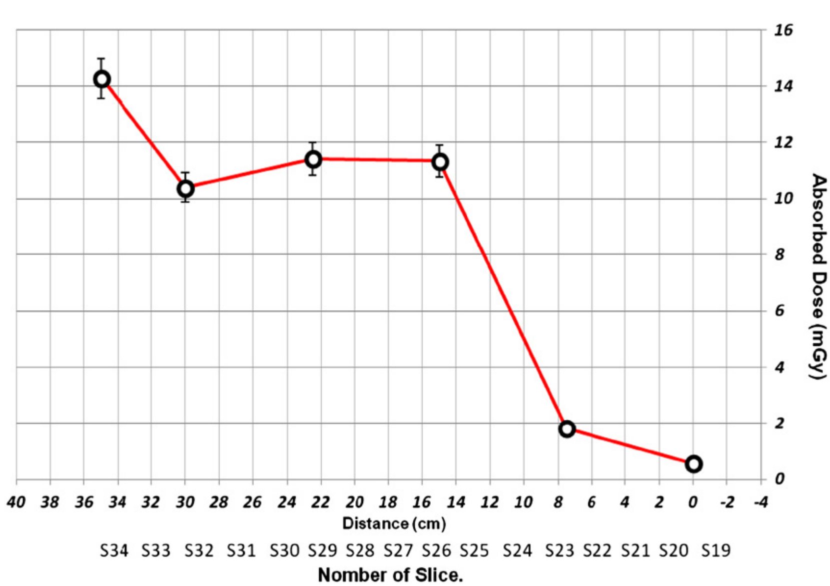

Fig. 4. Scattered radiation values in pelvis studies.

of absorbed dose are valid for helical CT in pelvis area; however, these values give a reference data for future CT measurements for other devices. The Mexican norm 229-SSA1-2002 (Proyecto de norma, 2002), is the only reference in Mexico, which reported reference values for CT studies in absorbed dose, only handles the area of head thorax and abdomen, specifically omitting the pelvis area. Radiation Protection 118. Referral guide lines for imaging (EURATOM), expressed in effective dose values, then the absorbed dose data for this type of study that is routine can only be compared with reports, managing the comparison as a reference approach.

4. Conclusions

Absorbed dose in pelvis area is determined by thermoluminescent dosimetry. The dose distribution is not uniform for the entire scan area, considering the field of scattered radiation, but it is for the primary beam area is the area of radiation useful for the study. The experimental results show a contribution of scattered radiation about 29% compared to uniform dose of useful primary beam. Thus, absorbed dose could be varied as due longitudinal distance from the interest area is moved. The increasing of the absorbed dose in critical organs is due to the completion of the study, involving the sum of the contribution in a way that cuts distributes tomography radiation.

Acknowledgments

The author thanks the Hospital Central Militar for their facilities for the preparation of this work, and the Consejo Nacional de Ciencia y Tecnologia for the financial support. (CONACYT).

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