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Determination of radiosensitive organs in head CT for the head area

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Abstract

Computed Tomography represents about 10% of all diagnostic radiology procedures, but it is responsible for almost 50% - 60% of exposure from diagnostic procedures. In head CT, other critical organs such as eye lenses and thyroids are in the radiation field. Therefore, dose assessment in these organs is very important. The aim of this study is to estimate the absorbed dose in critical organs of patients undergoing common head CT scans. In this study, the Radiosensitive organs in CT were determined in Razi hospital in Rasht, the capital of Gilan province in Iran. The standard head phantom that was built from ertalon and cheap termolominecene dosimeter LiF; Mg: Cu; P was used for dosimetry in organs. Height and diameter of the phantom which contained holes for placing the TLD were 32 cm and 16 cm, respectively. Readouts were obtained on a Harshaw reader. The results show that during head CT scan, the maximum absorbed dose belongs to occipital bone skin, that is 15.2mGy, and the minimum absorbed dose belongs to the neck, which is 0.13 mGy. For reduction of damage due to exposure in CT, it is necessary that the absorbed dose of organs be decreased.

Keywords*:* Aabsorbed dose; computed tomography; radiation; radiosensitive; termolominecene dosimeter

1. Introduction

X-ray imaging modalities make major contributions to the computed tomography (CT) (United Nations Scientific Committee on the Atomic Radiation, 1972). The computed tomography (CT) is probably the preferred technology for obtaining high resolution anatomical images of patients. CT images are composed oftransverse slices, which are obtained by an X-ray tube rotating around the human body. Computed Tomography (CT) has numerous applications in clinical procedures, but its main problem is its high radiation dose affecting the patients, when compared to other imaging modalities using x-ray. CT delivers approximately high doses to the nearby tissues due to the scattering effect, fan beam (beam divergence) and limited collimator efficiency (KarimiAfshar, 2009). In comparison with other radiographical procedures, patient absorbed doses in CT imaging are usually very high (Ferria, 2009). Exposure in CT can also create cancer (United Nations Scientific Committee on the Atomic Radiation. In recent decades much attention has been given to CT dosimetry. Worries concerning this phenomenon have increased with the rise in various usage of CT (Klement, 2000). Exposure in CT is much higher than radiography and fluoroscopy (Blus, 2003). CT imaging makes a significant contribution to exposure of medical radiation (Rogalla, 1999, Linton, 2003, UNSCEAR, 2000). Probability of radiation effects such as erithma, alopecia and also stochastic effects such as induced cancer and hereditary effects can be estimated by calculating the absorbed doses in organs (Linton, 2003, Shrimpton, 2005).

The number of CT examinations isincreasing every year. Take the United States for example, where it has increased to 4-6 percent (ICRP, 1990, IMV Market Statistics CT Census, 2004, Stern, 2006, Frush, 2004, Mettler, 2000). The computed tomography (CT) scans comprised only 10-15% of all radiological exams, but comprise 67-75% of the total radiation dose of the patient population (Frush, 2004, Mettler, 2000, Imhof, 2003, Rothenberg, 2001, Kaul, 1997, Galanski, 2000, Kudler, 2002). The dose of the patient during computed tomography (CT) examinations is (20-100) times higher than the dose received by the patient during conventional X-ray examinations (Wiest, 2002, Adliene, 2010). Assessment of radiation dose and its related risks to patients is animportant issue in radiation protection dosimetry (Hoseinian Azghadi, 2012). Regarding radiation protection and the ALARA principle, evaluation of doses in CT seems quite necessary.

A numerous investigations have been performed, and a number of different models have been created for the calculation of real patient doses in CT chest and abdomen examinations in the last decade, but

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there is still a lack of studies concerning the potential improvement of dose evaluations in head CT examinations (Wiest, 2002, Valentin, 2000, Baert, 2007, Staniszewska, 2005). Because of harmful radiation effects, in this study, we decide to calculate the absorbed dose due to CT for radiosensitive organs in the head region in order to later protect these areas from radiation.

2. Materials and Method

Radiosensitive organs' dosimetery for the head region in head CT was experimentally performed in Razi hospital using phantom equivalent soft tissue (Fig. 1). The height and diameter of the phantom were 32 cm and 16 cm, respectively. This phantom contained holes for chip TLDs with a kind of LiF; Mg: Cu: P. The phantom was exposed to X-rays due to head CT for dosimetry.

Fig. 1. Head phantom used in this research

The quantity of received radiation from TLDs is presented in Table 1 (in Coulomb unit).

Table 1. Reading of TLD in m Cunit

Organs	Frontal	Cheek	Occipital bones skin	Right eye	Left eye	Right ear	Left ear	Right thyroid	Left thyroid	Neck
Dose in mC unit	1471	82.2	3250	2720	2430	2000.1	1750	120.4	100.5	25.8

While the thermo luminescence dosimeter is a comparative one, the X-Ray system of secondary standard center of nuclear was used. Reading of TLDs in mC unit was transformed in absorbed dose unit by the calibrated system.

Calibration of dosimeter into ECC procedure

There are different responses to average value in all dosimeters of collection due to natural differences in sensitivity of thermo luminescence materials and chips mass. Dosimeters must be calibrated for redusing these factors. The dosimeters calibration factor (as Element Correction Coefficients or ECC) is defined as (Equation 1):

$$ECC_j = \frac{\langle TLE \rangle}{TLE_j} \qquad (1)$$

and;

$$TLE\rangle = \frac{1}{m}\sum_{j=1}^{j=m} TLE \qquad (2)$$

where j= 1, 2, 3 …& m is number of calibrated dosimeter and TLE_j is thermal efficiency for j-th dosimeter (Saint, 2002).

Calibration of dosimeter into RCF procedure

The Reader Calibration Factor of thermo luminescence materials, RCF, is a factor that transforms electric charges of the photomultiplier tube into mGy. The RCF is defined as;

$$RCF = \frac{\langle Q \rangle}{L}$$

(3)

where $\langle Q \rangle$ is charge mean that has been read by the dosimeters, and L is the quantity of the dose in terms of dosimetry units.

3. Results and discussion

In conclusion, we may inscribe the recorded absorbed dose, (D), in every TLD that can be calculated in terms of ECC and RCF as (Saint, 2002):

D= charge × ECC × RCF (4)

where RCF= 0.0048. The values of ECC and absorbed dose in every organ in mGy unit are presented in Tables 2 and 3.

Table 2. Values of ECC

TLD number	1	2	3	4	5	6	7	8	9	10
ECC	0.9509	0.9722	0.9726	1.020	0.9641	0.9500	1.048	1.047	1.016	1.029

Table 3. Absorbed dose in every organ in mGy unit

Organs	Frontal	Cheek	Occipital bones skin	Right eye	Left eye	Right ear	Left ear	Right thyroid	Left thyroid	Neck
Absorbed dose	6.4	0.38	15.2	13.3	11.2	9.12	8.8	0.6	0.5	0.13

The absorbed doses in the head organs are listed in Table 3. These show that, the received dose in the occipital bones, skin, and eyes is a very high one, due to being directly exposed to radiation. Absorbed dose in the occipital bones, skin, and eyes is 15.2mGy and 13.3mGy, respectively.

4. Conclusion

The obtained results show that the absorbed dosesin Computed Tomography are more than the absorbed dose in radiology. Range of dose in CT is several mGy whereas that of radiology is only a few thousands of mGy (Donald, 2003). Various experiments have been done similar to this subject. In (Laurence, 2010), the rate of absorbed dose for thyroid was about 0.37 mGy. In another experiment, the absorbed dose for frontal, cheek, occipital bones skin, right eye, left eye, right thyroid and left thyroid were estimated at 6.9 mGy, 0.35mGy, 11.45mGy, 7.14mGy, 7.55mGy, 0.54mGy and 0.5 mGy respectively (Haddadi, 2011). Also, in D. J. Mclaughlin's experiment, the absorbed dose was estimated by two techniques: first without any shield for organs and second with shield for some organs. Results of this experiment show that these changes in dose equate to 57% reduction in dose to the thyroid and 18% reduction in dose to the lens of the eye (Mclaughlin, 2004). Thus, in order to decrease X-Ray exposure due to CT scan in the head and thyroids, blinkers and thyroid guards must be used.

The absorbed doses for thyroids and the neck in our experiment are higher than received doses in radiography and this amount of dose can seriously damage the tissue, and cause cancer induced risks.

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