Arab J. Nucl. Sci. Appl., Vol. 56, 1, 112-116 (2023)

ISSN 1110-0451

Arab Journal of Nuclear Sciences and Applications

Web site: ajnsa.journals.ekb.eg

(E S N S A)

Radiation Dose to Radiosensitive Organs during Head/Sinus Computed Tomography Procedure

Taha Mohamed Taha

Radiation Protection Department, Nuclear Research Center, Egyptian Atomic Energy Authority, Cairo, Egypt.

ARTICLE INFO

Article history:

Received: 21st May 2022

Accepted: 15th Sept. 2022

Keywords:

Sinus CT scan,

TLD,

ESD,

Radiosensitive organs.

ABSTRACT

The current study aims to measure the entrance surface air kerma and absorbed dose to radiosensitive organs such as eyes and thyroid glands, due to scattered radiation during head/ sinus Computed Tomography (CT) scan. The entrance surface air kerma (ESAK) and absorbed dose for the eyes and thyroid of the Rando phantom's head were evaluated by distribution of the standardized thermoluminescence dosimeters at the surface and 10 mm depth for slices for eye and thyroid sections. The ESAK for eyes and thyroid during head/sinus CT examinations was, as follows: 29.73± 1.63 mGy for eyes and 26.12 ± 1.51 mGy for thyroid. The mean absorbed doses of $Hp_{(10)}$ to eyes and thyroid during the Rando phantom's head CT were 1.86 ± 0.02 mGy and 1.59 ± 0.08 mGy, respectively. The scientific study concluded that lowering scan length for the sinus CT scan is necessary to minimize a scattered dose to radiosensitive organs.

INTRODUCTION

Radiological procedures are the main man-made sources of radiation exposure to the patient. Computed Tomography (CT) is one of the most important tools for diagnosis, which can produce high-quality three-dimensional images, the number of CT examinations in diagnostic radiology increasing nowadays in various countries of the world. More than 90 % of the dose taken by population from all artificial sources is due to the diagnostic radiology procedures, and the CT examinations are responsible for more than two-thirds of these radiation doses, therefore it is considered a high-dose procedure [1]**.** CT examination contributes to about 43% of medical radiation doses taken by patients. It delivers radiation doses to patients that are higher than those from other radiological procedures [2].

There are scattered doses to eyes during head/sinus CT scans due to the absence of dose optimization. During head CT examinations, certain unnecessary doses are delivered to radiosensitive organs such as the eyes and thyroid. The International Atomic Energy Agency (IAEA) reduced the recommended exposure limit for eyes from 150 to 20 mSv, the threshold dose for non-stochastic radiation effect was reduced from 5Gy to 0.5Gy [3].The current research paper aims to assess the radiation risk to radiosensitive organs during a head CT procedure. Therefore, medical radiation protection principles should include justification and optimization by applying the ALARA principle, as low as reasonably achievable. The assessment of the entrance skin dose, ESD, for patients exposed to CT examinations should be performed in order to optimize the radiation protection of the patients. Moreover, assessment of the ESD for patients plays an important role in generating a skin dose baseline for the CT scanners**.** "Taha *et a*l, 2020, studied the dose–length product or volume-weighted CT dose index (CTDICvol) via picture archiving communication system (PACs) of 64-MDCT scanners which are displayed by the equipment, for evaluation of radiation doses and they are not focused on absorbed radiation dose to radiosensitive organs [4]. Some recent previous work examples related to radiation protection for radiosensitive organs during CT examination such as eye and thyroid gland are illustrated as follows. "Pavel Ryska *et al*. concluded that Iterative reconstruction of cerebral Multi Detector CT (MDCT) examinations enables reduction of both effective and organ eye lens dose by one third without significant loss of image quality [5]. Huda *et al*, reported that thyroid doses can be estimated by taking into account the amount of radiation used to perform the CT examination (CTDI(vol)) and accounting for scan length and patient anatomy (i.e., neck diameter) at the thyroid location [6]. The current

Corresponding author: tahaalfawwal@hotmail.com
DOI: 10.21608/ajnsa.2022.140014.1586

paper aims to measure **ESAK** and absorbed dose to radiosensitive organs, such as eyes and thyroid glands, during a head/sinus CT scan.

MATERIALS AND METHODS

The study was approved by the publication committee of atomic energy authority number 215 on 2 /4/2022.

Computed Tomography (CT) Specification

The utilized CT scanner (Toshiba 4 MDCT) slices are measued with a solid state detector. Scintillation detectors at one hospital in Cairo City are used in this study. The protocol parameters for sinus/head CT scan are as follows: 120 kV, 172 mAs $CTDI_{vol}$: 48.3 mGy, pitch factor 1.125, and dose length product of 333 mGy.cm. Measurement of ESAK to eyes and thyroid of Rundo phantom's head during sinus CT scan was carried out via three processes presented below.

Calibration of the thermo luminescence dosimeters (TLDs)

Calibration of the thermo luminescence dosimeters (TLD-100, LiF) includes several processes as follows: pre-irradiation annealing, irradiation to a constant dose of X-ray, pre-read annealing (preheating) sorting/ identification of the golden chips, irradiating- reading, and generating of the element correction coefficient and the calibration factor [4].

Generating thermoluminescence (TLD) dosimeters are placed on a 2.5 cm sheet thickness non water slab phantom, which is scanned using *sinus/head CT* parameters. The individual dose calibration factor for each TLD chip was calculated using the following equation.

$$\text{RCF} = \frac{\textit{Measured}\ \text{response (nC)}}{\textit{Actual received dose (mGy)}} \qquad (1)$$

Where:

RCF : Reader Calibration Factor, nC/mGy

Measured response (nC): Total net charges (nC).

Then, the mean calibration factor is calculated.

Two groups of master TLD chips were used for measurements of ESAK (mGy) to eyes and thyroid. Group number one consists of ten sets of master TLD chips. Each set consists of three TLD chips located on the slice section of the Rando phantom's head that corresponds to the position anatomy of the eyes. Alderson Rando phantom (Alderson Research Laboratories, Stanford, USA) was used. This phantom is molded of tissue-equivalent material, designed according to highly sophisticated technical constraints and following ICRU-44 standards. Phantom's soft tissue is manufactured from a proprietary urethane formulation with an effective atomic number and mass density that closely simulates muscle tissue with randomly distributed fat. Natural human skeletons are used for skeleton construction. The female phantom is 155 cm tall and 50 kg weight. The phantom is cut horizontally in 2.5 cm thick slices, resulting 32 slices. Each slice has holes that can be filled with TLDs as stated by the report of The Alderson Radiation Therapy Phantoms [7]. The second group of master TLD chips was used to measure the scattered absorbed dose to the thyroid during a sinus/head CT scan of a human body to generate an entrance skin dose (Figure 1). Each set consists of two TLD chips. The phantom's head with their TLDs were irradiated according the following parameters: 120 kV, 100mAs, scan length 106 mm.

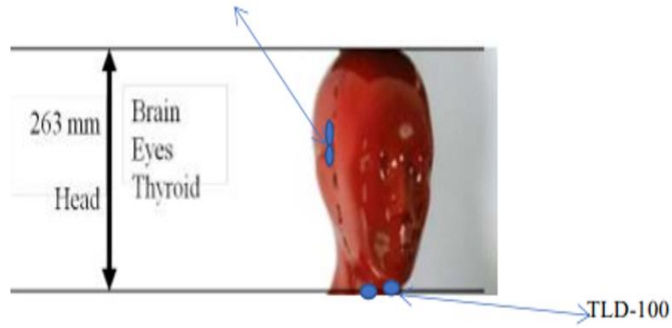

Fig. (1): Alderson Rando Phantom with Two TLD(s) each stacked across slices corresponding to eye (section 3) and thyroid (section 9) positions

Reading of the Dosimeters by Using a Thermo-luminescence Reader

Surface dose for the organs of interest is calculated using the following equation:

$$ESD_{Organ} = (M_{cts} - M_{BKG}) \times RCF \times ECC \times \left[\frac{\left(\frac{u_{en}}{\rho}\right)_{med}}{\left(\frac{u_{en}}{\rho}\right)_{air}}\right] \qquad (2)$$

Where

ESD_{organ}: is the entrance skin dose for organ of interest

M_{cts} : is the TLD measured counts after irradiation

M_{BKG}: is the TLD measured counts due to background radiation

RCF: is the reader calibration factor, 0.068 ± 0.009 mGy/nC

ECC: Element correction coefficient

(u_{en}/ρ) : is the mass energy absorption coefficient

Absorbed doses to eyes and thyroid of head Rando Phantom

Two and six thermo luminescence dosimeters were distributed inside eyes and thyroid slice sections, respectively, to measure absorbed dose at depth of 10 mm $hp_{(10)}$ of the Rando phantom's head that was scanned using Discovery CT750, with64 scanners (GE Medical Systems, LLC), a solid state detector and the head CT protocol parameters are: 104 kV, 74mAs, scan length 155 mm.

RESULTS AND DISCUSSIONS

The mean and standard deviation of the reader calibration factor was 0.068 ± 0.009 mGy/nC , with a coefficient of variation of less than 5%. The mean *ESAK (mGy),* for eyes and thyroid during head/sinus CT scan are presented in Figs. (2&3).

The mean scatter entrance skin dose for thyroid during sinus/head CT scan of Rando phantom's head was found to be 26.12 ± 1.51 mGy. The CT acquisition parameters were as follows: tube voltage, 120 kV, an effective milliamper second, 236 (mAs), and scan length of 106 mm. The measured absorbed dose secondary to scatter radiation dose to thyroid was found to be lower than the value of 36 mGy as reported by Ashgar et al. [8] and was found to be lower than the value of 28 mGy as reported by Toossi et al. [9] who measured a thyroid absorbed dose during neck CT examination using TLD-100. In addition, the measured absorbed dose secondary to scatter radiation dose to thyroid was within the dose range of the International Commission on Radiological Protection [10] .

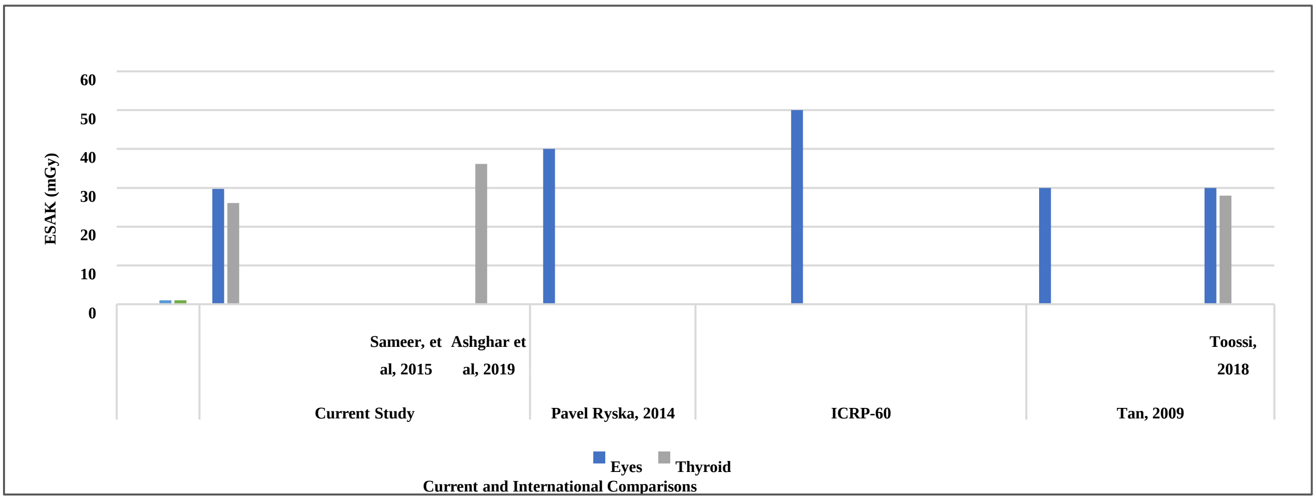

Fig. (2): The mean *entrance surface air kerma, ESAK (mGy),* for eyes and Thyroid and comparison with International Studies

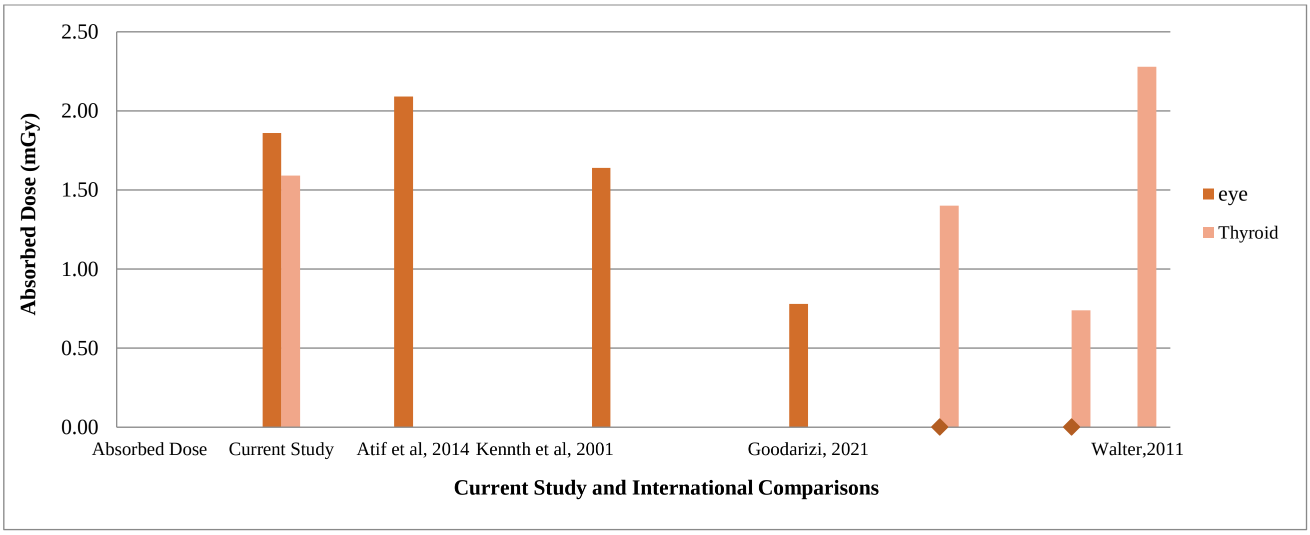

Fig. (3): The mean absorbed dose (mGy), for eyes and Thyroid and comparison with International Studies

The mean of absorbed doses, $Hp_{(10)}$, to eyes and thyroid during the Rando phantom's head CT were 1.86 mGy and 1.59 mGy, respectively. The absorbed eye dose measured by TLD is lower than the corresponding absorbed dose value of 1.64 mGy and 2 mGy mentioned by Kenneth *et al*. and Atif et al. respectively **, [**11-12**]** using TLD-100 and lower than the the value of 0.78 found by Goodarzi *et al*. who monitored the thyroid gland using radiosensitive radiographic emulsion during neck CT, [13]. The absorbed thyroid organ dose measured by TLD is lower than the corresponding absorbed dose value of 0.74 mGy mentioned by Hamid *et al*. and lower than the value of 2.28 mGy reported by Huda *et al*.**.**This may be due to a difference in the scan length [14][6].

CONCLUSIONS

The ESAK for eyes and thyroid during head/sinus CT examinations was as follows: 29.73± 1.63 mGy for eyes and 26.12 ± 1.51 mGy for thyroid. The mean absorbed doses of $Hp_{(10)}$ to eyes and thyroid during the Rando phantom's head CT were 1.86 ± 0.02 mGy and 1.59 ± 0.08 mGy, respectively. The scan length for the sinus/head CT may reduce the absorbed dose of the sensitive organs such as eyes and thyroid gland.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

REFERENCES

[1] Ali, Elmadi., Mohamed, Abuzaid., Essameledeen, Babikri., Abdulmoneim, Suleiman., (2017)) Radiation Dose Associated with Multi detector 64 slice Computed Tomography Brain Examinations in Khartoum state Sudan., Pol.J.Radiol, 2017; 82-603-606.

[2] International Atomic Energy Agency., (2011) International Basic Safety Standards for protecting people and the environment. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. General Safety Requirements Part 3. No. GSR Part3 (Interim), IAEA, Vienna (2011).

[3] International Commission of Radiological Protection., (2012) Statement on Tissue Reactions /Early and Late Effects of Radiations in Normal Tissues and Organs- Threshold doses for tissues reactions in a Radiation Protection Context. ICRP Publication 118. Ann ICRP 41(1/2).

[4] T.M.Taha., S.H.Alehyani., A.A.Mihdhir., M.Olataiby. (2020) Assessment of Diagnostic Reference Dose Levels Associated with Computed Tomography Examination . JNTAS ESERSA, 7(2).

[5] Pavel Ryska., Tomas Kvasnika., Jiri. Jamdra., Judura., Ludovit. Klzo., Jakub. Grepl., Janzizka., (2014) Reduction of effective dose and organ dose to the eye lens in head MDCT using iterative image reconstruction and automatic tube current modulation.Biomed Pap Med Fac Univ. Palacky Olomouc Czech Repub, 2014 Jun, 158 (2):265-72.

[6] Walter Huda., Dennise Magill., Maria V Spanpinato., (2011) Technical note: estimating absorbed doses to the Thyroid in CT.Med, Phys 2011.Jun; 38(6):3108-3013.

[7] Radiology Support Devices, The Alderson Radiation Therapy Phantoms. Radiology Support Devices, Inc. http://www.rsdphantoms.com/rt_art.htm

[8] Asghar Maziar., Reza Paydar., Ghazal Azadbackht., Daryoush Sharyoush Shahbzi-Gahrover.,(2019)Estimation of Absorbed doses to Thyroid gland in patients undergoing 64 slice head Computed Tomography and comparison the results with Impact software and CT scan dose index. Journal of Medical Signals and Sensors.

[9] Mohamed Taghi Bahreyni Toossi., Hoda Zara Zahra Eslam., Shahram Bayoani., Mohamed Daneshdoost., Said Zarif Ghasermiaz., Medi Sedighpaur., Nastasan Mohamedian., Sayed Mohamed Hashemi., Afsneh Khane., (2018) Assessment of Radiation dose to the lens of the eye and thyroid of patients undergoing Head and Neck Computed Tomography at Five Hospitals in Mashad, Iran. Iranian Journal of Medical Physics.

[10] International Commission on Radiological Protection., (1991) Recommendations ICRP publications 60 Ann. ICRP 21 (1-3) Oxford. Pergamum press.

[11] Kenneth D Hopper., Joel Neuman. Steven H., (2001) King and Allen R Kunselman.(2001). Radioprotection to the eye during CT scanning.AJNR AmJ Neuroradiology Jun; 22(6): 1194-1198

[12] Atif N. Khan., Waqas, Shuaib., Boris, Nikolic., Mohammad K. Khan., Jian Kang., and Faisal, Khosa., (2014). Absorbed Radiation Dose in Radiosensitive Organs Using 64- and 320-Row Multidetector Computed Tomography: A Comparative Study. Hindawi Publishing Corporation Scientifica, Article ID 305942, 6 pages http://dx.doi.org/10.1155/2014/30594.

[13] Amir Hosein Goodarzi., Masaneh Sanei., Hadi Hassanzad., Zohreh Khosravi., Ahmed Bitarafan-Rajab., Alireza Emdi.,(2022) Measurements of effective dose to head and Neck critical organs in Computed Tomography Journal of Chemical Risks. JCHR,12(0).

[14] Hamid GHAZNAUI., (2020) Thyroid Cancer in patients undergoing 64 slice brain and par nasal sinuses Computed Tomography.