International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Measurements Absorbed Doses to Some Organs during Head CT Imaging

T. M. Taha[1, 2], S. H. Allehyani[2]

[1]Physics Department, Faculty of Applied Sciences, Umm Al-Qura University, KSA, P. Box 21955

[2]Radiation Protection Department, Nuclear Research Center, Atomic Energy Authority

Abstract: ***Purpose to measure absorbed doses to brain, eyes and thyroid organs during head computed tomography imaging. Materials and Methods: Thermoluminscence dosimeters, TLD-100 placed inside the Head CT dosimetry phantom at four peripheral and central holes and irradiated to reference dose of CT beam. Results: The weighted dose conversion factor for TLD(s) at four peripheral holes and central hole of head phantom, at 120 kV and 400 mAs is generated. The mean absorbed doses to brain, eyes and thyroid during head CT protocol using phantom of human are found to be 1.02 mGy, 1.17 mGy and 0.99 mGy respectively. Conclusion: The mean absorbed doses to brain, eyes and thyroid organs are lower than International Commission of Radiological Protection recommendations.***

Keywords: Computed tomography (CT), Head and body CT phantom, CTDI, Ray safe

1. Introduction

Radiation doses delivered to patients during CT imaging represents 4-5 % of all radiologic examinations and contributes about 34-35% of the annual collective dose from all medical X-ray examinations to the population from radiological examinations (Nagel et al, 2000 and UNSCER, 2000). In large U.S. hospitals, CT represents 10% of diagnostic procedures and accounts for approximately 65% of the effective radiation dose for all medical examinations (National Cancer Institute,2006). Thyroid and the eye lens are organs considered sensitive to ionizing radiation and brain is one organ insensitive to ionizing radiation (Maylase, 2018). the International Commission on Radiological Protection (ICRP-103, 2007) lowered radiation weighting factors for some organs, thyroid gland gonads from 0.02 to 0.08 and thyroid from 0.05 to 0.04 and others organs does not change such as bone surface, skin, brain, salivary glands, 0.01. The mentioned weighted tissue factors express the stochastic radiation effect. it is the largest source of radiation dose. This study is aimed to generate procedure for measurement absorbed doses to eyes, brain and thyroid organsduring Head CT Imaging.

2. Material and Method

Calibration of TLD(s) placed inside the Head CT dosimetry phantom

Group sorting and identification of golden and master chips

After irradiation all the 120 thermoluminscence dosimeters, TLDs were assigned into ten sorted group based on their 'sensitivity'; according to their collected charge in nC in various ranges. The chips having approximately the equal sensitivity were grouped together. TLDs of LiF: Ti (TLD-100) with 3.5mm diameter and 0.15mm thickness were used to evaluate organ doses. TLDs were read out in a manual TLD reader (Harshaw 3500, Thermo Fisher Scientific) with a hot planchet heating mechanism using the WinREMS Software. The read-out cycle for TLD-100 preheating at 50◦C for 10s, and a linear ramp rate of 5◦C/s to 300 ◦C for 25s. The annealing of TLDs was adjusted to 400◦C for 1 hour and to 100 ◦C to two hours in a microprocessor-controlled oven (PTW manufacture), followed by cooling to room temperature on an aluminum block. Element correction coefficient (ECC) improved the relative sensitivity of TLDs to correct the variation of individual sensitivity in the batch and calculated using the following equation

$$ECC = \frac{\text{TLD response}}{X}$$

Where
ECC: Element correction coefficient
TLD response: Reading for each TLD chips, nC
X: mean of the the TLD chips, nC

Five groups of master TLD(s) chips were selected, placed inside the center and peripherals of head CT dosimetry phantom as a procedure mentioned by (M. Zelikman *et al*, 2012). Four groups of the selected TLD-chips, placed inside peripheral of head phantom. Each group is consisting of 10 TLD chips. One group of the selected TLD-chips placed inside center of head phantom. these TLD-chips calibrated in the CT beam on an axial scan obtained with acquisition parameters of 400 mAs and 120 for the head imaging. In calibration, the reference air kerma was measured with a 100 mm CT pencil ionization chamber that inserting at hole center and four peripherals CT head phantom connected with Ray safe electrometer by the same physical operating parameters similar to that irradiated the master TLD(s) chips. Computed tomography dose index, CTDIw represents the average dose over the central plane of a 100-mm scan length is calculated using the following equation.

$$Cw = \frac{1}{3}C_{PMMA,100,c} + \frac{2}{3}C_{PMMA,100,p})$$

The quantity $C_{PMMA,100,c}$ is measured at the center of the standard CT dosimetry phantom and $C_{PMMA,100p}$ is the average of values measured at four positions around the periphery of the phantom.. Element correction coefficient for individual TLD calibrated have repeatability lower than 3.5%.Ten head human phantoms containing TLD(s) chips in position of the brain, eyes and thyroid organ irradiated to the

mention head CT protocol.the reader calibration factor is calculated by the following equation.

$$RCF = \frac{\text{TLD response, nC}}{Cw}$$

Where:
RCF : Reader Calibration Factor, mGy/nC
TLD response = Total net charges (nC).
Cw: the average dose over the central plane of a 100-mm scan length

The distribution of TLD(s) for each head phantom is designed as follows, sixteen TLD(s) chips inserted in brain organ, two chips in eye organ and three ships in thyroid organ (Ernest M. *et al*, 2008).

Calculation of effective dose

Effective doses are calculated by weighting absorbed dose, H_T , by the tissue weighting factor ($W_{T)}$, by the tissue weighting factor (W_T) and summing over the tissue, E can be represented as mentioned by (ICRP-103, 2007) as following:

$$Effectivedose = \sum WTHT$$

Where: WT: Tissue weighting factor
H_T: Equivalent dose
E: Effective dose

3. Results

The weighted calibration factor was generated for the golden chips in head CT dosimetry phantom , DCF_h, 0.00234 mGy/nC at CT beam of CT acquisition factor , 120 kV and 400 mAs using head CT phantom. The absorbed doses to brain , eyes and thyroid organ are calculated during imaging of head of Rando phantom. The absorbed doses for Brain, eyes and Thyroid organ position in head Rando phantom CT scan is measured by distribution thermoluminscence dosimeters in Brain, eyes and Thyroid organ position in head Randophantom as presented in table.1

Table 1: Absorbed organ doses (mGy), brain, eyes and thyroid of Head Rando phantom

Organ	Absorbed dose mGy		
	Minimum (mGy)	Maximum(mGy)	Mean (mGy)
Eyes	1.85	1.86	1.86
Brain	2.33	1.23	1.65
Thyroid	1.57	1.63	1.59

4. Discussion

The $CTDI_w$ is a useful indicator of scanner radiation output for a specific kVp and mAs. It represents the average absorbed over the central plane of a 100-mm scan length. The weighted CT kerma, Cw combines values of $C_{PMMA,100}$ measured at the center and peripheral of the standard 16 cm head and 32 cm body phantoms.The mean absorbed doses to eyes, brain and thyroid during head Rando phantom CT are 1.86 mGy, 1.65 mGy and 1.59mGy respectively. Effective doses are calculated using tissue weighting factors of ICRP-103,2007). The mean effective doses to position of brain and thyroid during head Rando phantom CT are 0.02mSv and 0.06mSV respectively. The mean organ doses for eyes and thyroid are lower than ICRP recommendation. (ICRP-78). In comparison, a study on the phantom of human with TLD-100 dosimeters, in which head spiral scanning was performed by General Electric scanner, mean effective dose by thyroid and brain were estimated 0.06 mSv and 0.02 mSv. Some authors such as Jeff *et al*, 2010, Changizi *et at*, 2018 and Asghar Maziar *et al*, 2018 estimated the dose to thyroid in Brain CT scan with a multi slice scanner by TLD-100 dosimeter to the 0.04 mSv .Thisamount is lower than calculated value in this study. In comparison with entrance skin dose to eye lens are varied from 4.9 mGy 19.7 mGy using high sensitive metal oxide semiconductor field effect transistor (Mosfet) (Ulla Nikupaavo et al, 2015) and (ICRP-78, 1997) mentioned organ dose to eyes during head scan increase until 50 mGy. The internal eye organ dose measured by TLD is lower than that entrance skin dose mentioned by ICRP-78) because head anatomy and skull density attenuate the x-ray radiation resulted from computed tomography.

5. Conclusion

Calibration of TLD(s) placed inside the Head CT dosimetry phantom improve the repeatability to be lower than 3.5% and decrease the distortion of x-ray. The internal eye organ dose measured by TLD is lower than that entrance skin dose due to head anatomy. The mean absorbed doses to brain, eyes and thyroid organs during head computed tomography imaging are measured and strongly lower than the ICRP recommendation. Dose delivered to sensitive organs during CT head imaging is optimized by using the physical CT acquisition parameters for head imaging at 400 mAs and 120 kV.

6. Ethical Statements

This study is approved by Institution review board (IRB) number A 00575 from the King Abdullah Medical Complex, KAMC, Jeddah, KSA.

7. Acknowledgments

This work is supported by Radiology Department of King Abdullah Medical Complex, KAMC, Jeddah, KSA.

References

[1] Nagel H, Galanski M, Hidajat N, Maier W, Schmidt T. Radiation exposure in computed tomography: fundamentals, influencing parameters, dose assessment, optimization, scanner data, terminology. Paper presented at the COCIR 2000, Frankfurt, Germany.
[2] United Nations Scientific Committee on Effects of Radiation Atomic Radiation (UNSCEAR) Sources and effects of ionizing radiation report to the general assembly. New York: United Nations; 2000.
[3] Radiation risks and pediatric computed tomography (CT): a guide for health care providers. National Cancer Institute Web site.

www.cancer.gov/cancertopics/causes/radiationrisks-pediatric- CT. Published August 20, 2002. Accessed October 6, 2006.

[4] Mary, Alice Statkiewicz Sherer, Paula J. Visconti, E. Russell. Riteneur and Keli welchltayness. " Radiation Protection in Medical Radiography. 8th edition , 2018.

[5] International Commission on Radiological Protection (ICRP). The 2007 Recommendations of the International Commission on Radiological Protection; ICRP publication 103; Oxford: Pergamon Press; 2007.

[6] M. Zelikman, S. Kruchinin, E. Isaycheva; Moscow/RU. Calibration of thermoluminescent dosimeters placed inside the anthropomorphic phantom which is used for CT effective dose evaluation; Congress: ECR 2012.

[7] Ernest M. Scalzetti,* Walter Huda,† Shashank Bhatt,* and Kent M. Ogden. A Method to obtain mean organ doses in a Rando phantom. Health Phys. 95(2):241–244; 2008.

[8] Ulla Nikupaavo[1,2], Touko Kaasalainen[1,3], Vappu Reijonen[1], Sanna-Mari Ahonen[2.] Lens Dose in Routine Head CT: Comparison of Different Optimization Methods With Anthropomorphic Phantoms; Medical Physics and Informatics, Volume 204, 2015.

[9] Jeff TA, Hoang JK, Yoshizumi TT, Toncheva G, Lowry C, et al. Radiation dose for routine clinical adult brain CT: Variability on different scanners at one institution. AIR Am J Roentgen, 2010.

[10] Changizi V, Mohammad F, Ali E. Investigating and comparing safety level of thyroid and eye effective radiation dose in cranial multi slice CT scans . J. Payavard Salamat. 2018; 2018.

[11] Asghar Maziar , Reza PAYDAR, Ghazal Azadbakht, and Daryoush Shabazi –Gahrouei. Estimation of Absorbed Dose computed tomography and comparison the results with Impact software and computed tomography scan dose index., J Med Signals Sens. 2019 Jul-Sep; 9(3): 190-195., 2019.

[12] International Commission on Radiological Protection (ICRP). Patient and staff Radiological Protection in Cardiology Protection in Cardiology; ICRP publication 78; Oxford: Pergamon, 1997.