Short Communication

Estimation of Absorbed Dose of the Thyroid Gland in Patients Undergoing 64-Slice Head Computed Tomography and Comparison the Results with ImPACT Software and Computed Tomography Scan Dose Index

Asghar Maziar[1], Reza Paydar[1], Ghazal Azadbakht[1], Daryoush Shahbazi-Gahrouei[2]

[1]Department of Radiation Sciences, Radiation Biology Research Centre, School of Allied Medicine, Iran University of Medical Sciences, Tehran, Iran, [2]Department of Medical Physics, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

Abstract

Thyroid exposure to radiation in brain computed tomography (CT) scan is of great value since it is considered as a vital organ. This study aimed to investigate the absorbed dose of thyroid by various protocols of head CT in patients referring to 64-slice CT scan center and to compare the values with the calculated dose by imaging performance and assessment of CT (ImPACT) method. Also, the values of CT scan dose index (CTDI) were calculated with semiconductor detector. In this cross-sectional study, 120 outpatients including three groups of forty individuals over 40 years old referring to the hospital radiology centers in Tehran for head CT were chosen and 3 thermo-luminescence dosimeter (TLD-GR200) were applied on thyroid gland of each patient. For brain CT, Absorbed and effective doses of thyroid gland were calculated by ImPACT software. In addition, semiconductor detector in head CTDI phantom calculated CTDI for the applied protocols. Mean effective dose of thyroid gland in brain scan group was calculated by TLD and ImPACT software which showed no significant difference ($P < 0.001$). Mean effective dose of thyroid gland in unidirectional and bi-directional sinus scan by TLD and ImPACT software were different significantly ($P < 0.001$). Also, the differences between CTDI values shown by brain and sinus scan protocol with semiconductor detector and those CTDI were significant ($P < 0.001$). The calculated values of absorbed dose and effective doses of thyroid by TLD and ImPACT software were not significantly different. Mean effective dose calculated for thyroid gland in head scans by TLD and ImPACT was less than the annual permissive level for thyroid gland suggested by International Committee on Radiological Protection. In this study, calculated values of thyroid effective dose in brain scan with 64-slice scanner were less than the calculated values in a similar study.

Keywords: *64-slice computed tomography, absorbed dose, computed tomography scan dose index, dose calculation, thermoluminescent dosimeter, thyroid cancer*

Introduction

In developing countries, about 70% of diagnosis tests are performed by X-ray radiation.[1] Ionizing radiation, such as X-ray, can cause damage to body tissues, especially sensitive organs to radiation. In x-ray imaging of the skull, thyroid gland is one of the sensitive organs to radiation.[2]

The incidence of thyroid cancer appears to be increasing worldwide.[3] In the USA, for example, there was an increase from 3.6/100,000 in 1973 to 8.7/100,000 in 2002, i.e., a 2.4-fold increase.[4] In China, the incidence of thyroid cancer was also increasing in recent years, has increased by 14.51% for females during 2003–2007.[5] In China, the thyroid cancer incidence for females increased from 1.3 per 100,000 in 1981 to 4.2 per 100,000 in 2001.[6] As well as, ability to detect thyroid cancer, this increase may reflect changes in environmental factors, such as increase in medical exposure to ionizing radiation from diagnostic imaging, especially during childhood, which is one of the few established risk factors for thyroid cancer and a large proportion of it due to the high use of computed tomography (CT) scan.[7-9]

Thyroid is one of the organs considered sensitive to ionizing radiation and has been shown to have especially increased sensitivity to radiation exposure in young

For reprints contact: reprints@medknow.com

How to cite this article: Maziar A, Paydar R, Azadbakht G, Shahbazi-Gahrouei D. Estimation of absorbed dose of the thyroid gland in patients undergoing 64-slice head computed tomography and comparison the results with ImPACT software and computed tomography scan dose index. J Med Signals Sens 2019;9:190-5.

Received: August, 2018. **Accepted:** December, 2018.

Address for correspondence:
Dr. Asghar Maziar,
Department of Radiation Sciences, Radiation Biology Research Centre, School of Allied Medicine, Iran University of Medical Sciences, Tehran, Iran.
E-mail: maziar.a@iums.ac.ir

Access this article online

Website: www.jmssjournal.net

DOI: 10.4103/jmss.JMSS_40_18

Quick Response Code:

children.[10] Although the new recommendations of the International Committee on Radiological Protection (ICRP) assigned a weighting factor of 0.04 to the thyroid, which is lower than the previous recommendation of 0.05 and three times lower than other sensitive organs such as the breast, lung, colon, stomach and bone marrow (each has a weighting factor of 0.12) it should be noted that these weighting factors are averaged over a wide range of ages.

Given that cancer risk from radiation, due to its stochastic nature, has no definite dose threshold; with the probability of its incidence increasing linearly with the dose quantity, quantifying thyroid dose is the factor to assessing thyroid cancer risk. It was estimated that, from the life of atomic bomb survivors, the attributable fraction of thyroid cancer from doses <100 mGy is about 4%, with a strong inverse correlation between the risk of cancer and age at exposure.[10] In CT examinations, the highest doses to the thyroid gland result primarily from neck and chest scans, and to a lesser extent scattered photons from head scans. The important factors of thyroid dose in CT, including protocol parameters, (mAs, kVp, pitch), scanner-related factors (detectors configuration, sensitivity and filtration) and patient sizes.[11] In the last 30 years, CT scan has become an inevitable tool for diagnosis and treatment of diseases. Major disadvantage of the mentioned method is its relatively high radiation dose compared to other imaging modalities with X-ray according to the reports of International committee on Radiation Protection.[12] Application of multi-slice CT scan devices is significantly increasing for their higher speeds and higher resolutions of images in these scanners.

As direct and indirect radiation of thyroid gland is highly probable in head scan, it is necessary to estimate the absorbed dose of thyroid gland in patients undergoing these examinations. Many studies were conducted considering estimated absorbed dose by thyroid gland on human simulator phantom, and in children,[13,14] but with our the best knowledge there is no studies on the evaluation of absorbed dose by thyroid gland in different protocols of head CT with 64-slice CT scan device.

Methods

A hundred and twenty adult patients by 40–85 years old, who referred to CT scan unit of hospitals in Tehran for brain and sinus scan were chosen randomly. In order to estimate the absorbed dose by thyroid gland in three protocols of head scan, namely, brain scan and uni-directional and bi-directional sinus scan, 3 groups consisting of 40 patients were selected.

Thirty-one thermo-luminescence dosimeter (TLD), commercially called TLD-GR200 (LiF; Mg, Cu, P), were applied and annealed for 10 min in 245°C. They were further placed in room temperature until reaching 25°C. TLDs were dose-calibrated using a ^{137}Cs source located in the nuclear of atomic energy in Karaj, Iran. All TLD doses were read using the TLD reader (Model. 3500, Harshaw, Solon, Ohaio, USA) located in the Department of Radiation Science of Iran University of Medical Sciences, Tehran, Iran. The mean TLD doses were calculated according to the calibration curve formula which described previously.[15] Then, three TLD tablets were stuck to the skin area of thyroid gland by anti-sensitivity glue. After CT imaging, the mean TLD doses were calculated according to the calibration curve formula which described previously.[15]

Calibration curves were drawn after reading TLDs [Figure 1]. Each TLD was placed in a tight translucent thin plastic cover so that it was protected from chemical and physical harm. TLDs were further read by TLD reader (Harshaw 3500, USA) and WinRems Software (Bicron Company, USA).

Imaging protocols were done by 64-sliced CT scan (Siemens, Germany). Scanning conditions for brain scan were as follows: kV = 120, mAs = 200, slice length = 1.2 cm, FFD = 160 cm, total scanning time = 8 s and length of the scanned area was ranging between 12.5 and 13 cm, rotation time = 0.5 s, Slice number = 7–8, based on the patient. Furthermore, scanning conditions for sinus scan were as follows: kV = 100, mAs = 90, slice length = 1.2 cm, FFD = 160 cm, total scanning time for uni-directional scan = 6 s and total scanning time for bi-directional scan = 8 s. Rotation time = 0.5 s, Slice number = 6–7. Also, the lengths of scanning area according to the patient for uni-directional and bi-directional sinus scan were 12–13.5 cm and 13–14 cm, respectively.

Calculation of absorbed and effective doses of thyroid for patients undergoing scanning with different protocol was performed using ImPACT software (Version 0.99x, PHE Company, London, UK).[16] In this respect, data associated with scanning such as kV, mAs, length and width of the scan, and CTDI were recorded in input file of ImPACT software, and effective and absorbed doses of thyroid were calculated for studied patients.

This software is used for the calculation of absorbed and effective doses of patient's organs who undergo CT scan procedures. This software performs according to the Monte Carlo simulation method which recommended by National

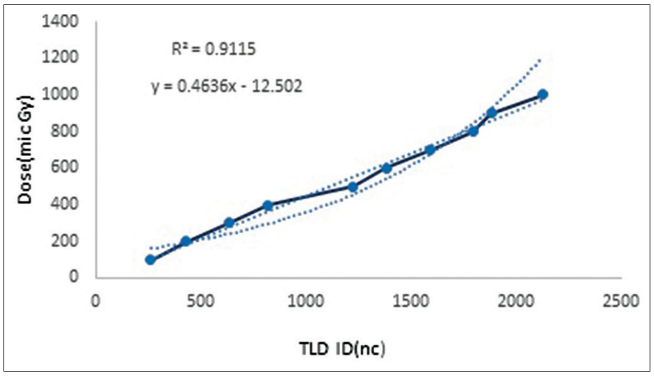

Figure 1: Calibration curve of thermo-luminescence dosimeters

Radiological Protection Board. Specific forms were prepared for recording the characteristics of the patients and scanning conditions including major parameters of the system.

In order to calculate the CT scan dose index (CTDI), semiconductor detector in head CTDI Polymethylmethacrylate phantom (PMMA, PTW Company, Germany) was used. An array of detector with the length of 10 cm was located in the middle part; however, in dosimetery, it is located in one of the detecrors of phantom so as to be just in the middle. Head CTDI phantom with the diameter of 16 cm was used. Phantom was placed on CT couch in such way that the center of the scanner was in the center of the phantom. This phantom consists of a central chamber and four peripheral chambers. After setting the major parameters of scanner device for the applied protocols, for calculating CTDI of each protocol, detector was at first placed in the central chamber of phantom and the remaining chambers were filled with bars made from the same materials as phantom. Then, detector was located in peripheral chambers at 3, 6, 9, and 12 o'clock, respectively. To determine the CTDI value, detector was attached to the electrometer (Piranha electrometer), which was attached to CTDI via Bluetooth. The illustrated values in the software, were recorded in a specific table and CTDI value for each protocol was calculated according to the following equation.[17]

$$\mathrm{CTDI} = \frac{1}{2}\,\mathrm{CTDI}_c + \frac{2}{3}\mathrm{CTDI}_p \ (\mathrm{mGy}) \qquad (1)$$

Where CTDI_c, is the calculated CTDI in the central chamber of head phantom and CTDI_p is the mean value of the calculated CTDI in positions of 3, 6, 9, and 12 o'clock of the head phantom.

Data were analyzed using SPSS Software version 18.0 (IBM Armonk, NY, USA). Pearson Correlation Coefficient was used to evaluate the correlation between different parameters. In addition, two-way ANOVA variance analysis was used to evaluate the relationship between different groups in two tests of calculating dose.

Results

As indicated in Tables 1-3 mean doses of thyroid radiation in brain scan using TLD and ImPACT software were calculated 0.34 mGy and 0.22 mGy, respectively. Also, mean doses of thyroid in bi-directional sinus scan using TLD and ImPACT software were calculated 0.66 mGy and 0.28 mGy, respectively. Calculated mean doses for different groups significance of the mutual effect means that the intensity of impact of experimental groups on thyroid dose is highly dependent on the method used for dose estimation [Figure 2].

Pearson correlation coefficient was used in order to calculate the correlation between the calculated dose by TLD and ImPACT software and the length of the scanned region in the study groups. The results of Two-Way ANOVA variance analysis are presented in Table 4.

In Figure 3 alterations of calculated mean dose in experimental groups are obviously clear. In order to calculate CTDI of 64-slice CT scan (console) by semiconductor detector in head CTDI phantom, CTDI values in each scan were recorded for central and peripheral chambers. Additionally, CTDI value shown on the device for each scan was recorded in a specific table. Then, the values were putted in Eq. 1 and CTDI values were calculated. CTDI values using diode for brain and sinus were obtained 36.18 and 9.77 mGy, respectively.

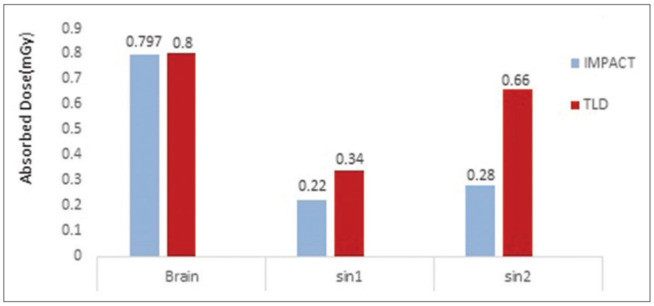

Figure 2: Comparison of mean doses of three groups using two methods of dose calculation

Table 1: Calculated mean and standard deviation of doses with Thermo-luminescence Dosimeter-GR200 in three studied groups

Type of scan	Minimum absorbed dose by thyroid (mGy)	Maximum absorbed dose by thyroid (mGy)	Mean (mGy)	SD
Brain	0.69	0.91	0.80	0.05
Uni-directional sinus	0.23	0.48	0.34	0.05
Bi-directional sinus	0.53	0.74	0.66	0.05

SD – Standard deviation

Table 2: Calculated doses of mean and standard deviation in three studied groups using imaging performance and assessment of computed tomography

Type of scan	Minimum absorbed dose by thyroid (mGy)	Maximum absorbed dose by thyroid (mGy)	Mean (mGy)	SD
Brain	0.75	0.85	0.79	0.05
Uni-directional sinus	0.19	0.25	0.22	0.03
Bi-directional sinus	0.24	0.32	0.28	0.03

SD – Standard deviation

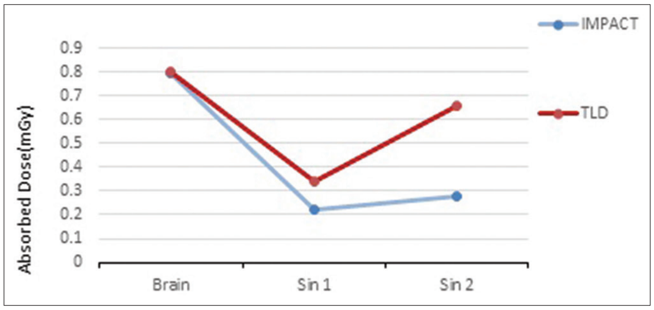

Figure 3: Alterations of mean dose in studied groups

Meanwhile, the scanner showed the values of 29.32 and 7.98 mGy for brain and sinus, respectively.

After calculating CTDI values for the conditions used in the current study and the protocols used with head CTDI semiconductor in head CTDI phantom, difference level was estimated to be 18.5% after comparing CTDI values shown on the scanner and the calculated CTDI values [Table 5].

Discussion

Today, the widespread use of CT scan has led to the increase in radiation dose of the patients and subsequently an increase in the incidence of cancer in particular in thyroid as a sensitive organ to radiation.[18,19]

The current study, investigates the absorbed and effective thyroid doses of patients experiencing head CT with brain scan, using uni-directional and bi-directional protocols. The evaluation of dose is carried out by TLD and ImPACT software.

Results showed that the mean dose of thyroid is different in three study groups with both evaluation methods. Mean absorbed dose by thyroid in brain scan was higher than the values calculated in bi-directional sinus scan and the latter was higher than the uni-directional sinus group. The calculated mean dose in uni-directional sinus group has significantly decreased with both methods but this decline has been higher in ImPACT method as illustrated in Figure 2. Furthermore, calculated mean dose in bi-directional sinus group increased compared to the uni-directional sinus, but this increase was significantly higher in TLD method in contrast to ImPACT method.

Mean dose calculated using ImPACT for uni-directional sinus group is evidently lower than the values calculated by TLD method (two error bars do no overlap), and the slope of increasing dose calculated by TLD method in bi-directional sinus group was much more steeper than the values calculated by ImPACT method [Figure 3]. As can be seen from tables the effects of the group and dose estimation method were statistically significant ($P < 0.001$). In addition, the mutual effect of group-estimation method was significant ($P < 0.001$). Owing to the significance of mutual effects, main effects were uninterpretable.

Table 3: Correlation between the calculated dose with Thermo-luminescence Dosimeter and the length of scanned area in different groups

Study groups	Correlation	*P*
Brain	0.385	0.014
Uni-directional sinus	0.774	0.000
Bi-directional sinus	0.779	0.000

Table 4: Mutual effects of group, method and group method in the test

Tests of between-subjects effects
Dependent variable: Dose (mGy)

Source	Type III sum of squares	df	Mean square	*F*	Significant
Group	10.922	2	5.461	2752.818	0.000
Methods	1.770	1	1.770	892.172	0.000
Group × methods	1.526	2	0.763	384.692	0.000
Error	0.464	234	0.002		
Total	78.780	240			

Table 5: Computed tomography scan dose index values by semiconductor in head computed tomography scan dose index phantom

Calculated CTD with detector (mGy)	CTDI of console (mGy)	Width of the scan	mAs	kV
36.18	29.32	1.2	200	120
9.77	7.979	1.2	90	100

CT – Computed tomography; CTD – CT scan dose; CTDI – CT scan dose index

Difference in main parameters of the device including kV and mAs can be accounted for alterations in dose which was shown to be higher in brain scan rather than sinus scan.[18] Length of the scanned area is an important parameter in absorbed doses by thyroid in different groups.[19] Mean length of the scanned area was 12.37 cm in brain scan, 12.98 in uni-directional sinus scan, and 13.45 cm in bi-directional sinus scan. It could be concluded that increase in length of the scanned area in bi-directional sinus scan, in spite of using similar kV and mAs in uni-directional and bi-directional sinus scans, can result in the increase in mean dose absorbed by thyroid gland in this group.

By comparing mean absorbed dose by thyroid using two calculating methods, it was shown that mean dose absorbed by thyroid in brain scan are almost similar in both methods; however, mean doses absorbed by thyroid in uni-directional and bi-directional sinus scans were different in two methods of evaluating dose. As ImPACT software calculates the absorbed and effective doses in different body organs based on radiation factors and CTDI values, and the length of the scanned area by Monte Carlo equations on phantom, same values will be calculated in constant radiation conditions. Furthermore, difference in scanner type and concordance of input data for new scanners and difference in the protocols in different units can lead to the difference in calculated dose by this software.

One of the factors affecting calculated absorbed and effective dose by the software can be the length of the scanned area, which is higher in bi-directional sinus scan compared to uni-directional scan. Another factor is using page factor 0.9 for bi-directional sinus scan, which accounted for the increase in the calculated dose by the software. As radiation condition in brain scan group is tenser than uni-directional and bi-directional sinus scan groups, increase in the mean dose in this group compared to the other two groups is not off limit in the current study.

It should be noted that conventional and spiral scanning are not defined in ImPACT software.[20] Also, scanned region consists of two areas of body and head in this software, and different scanning protocols are not defined. Calculations of this software are performed based on the calculations of brain scan. Additionally, different positions of the patient are not evaluated in this software. Mean dose in brain scan group for two methods of dose calculation were not significantly different; hence, ImpACT software can be used in calculating the effective and absorbed doses of patients going through brain scan. According to ICRP 60, maximum absorbed dose by thyroid in non-working individuals should not exceed 3 rem or 0.03 Sv.[12]

Mean effective doses of thyroid in brain scan group calculated with TLD and ImPACT equaled 0.040 and 0.011 mSv, respectively. Besides, the aforementioned doses in sinus scan were 0.033 and 0.014 mSv, respectively. It was noted that mean effective dose did not exceed from the values suggested by ICRP (30 mSv/y). In contrast, a study on the phantom of human with TLD-100 dosimeter, in which head spiral scanning was performed by Siemens scanner, mean absorbed dose by thyroid was estimated 0.025 mSv.[21] In another study, mean effective dose of thyroid in patients experiencing head scan without thyroid shield was estimated 0.04 mSv. These values are in concordance with the mean effective doses of thyroid in brain scan, calculated in the current study.[22] In the study of Diekmann *et al*. conducted on the Rando-Alderson phantom undergoing brain scan with 64-slice scanner, effective and absorbed dose of thyroid was estimated to be 0.06 mSv using TLD-100, which is higher than the calculated values in the current study.[23] In addition, in another study conducted by Fujii *et al*., mean effective dose of adult thyroid in rib cage and abdomen scan with Siemens 64-slice scanner were estimated 0.99 and 0.025 mSv, respectively. By comparing the results of the aforementioned study and the current investigation, it could be concluded that absorbed dose by thyroid in patients undergoing brain scan is higher than the calculated values in abdomen scan and lower than rib cage scan.[24] In the study Zammit Maempel *et al*. in 2003, calculated dose of the thyroid gland was calculated in the sinus scan with the multislice CT scan at coronal scan 2.9 mGy and in the Axial scan 1.4 mGy, which 0.4 mGy reduced the values in the calculations of the impact.[22] In another study by Jaffe in 2010, the thyroid dose is estimated at 0.03–0.28 cGy in Brain scan at anthropomorphic phantom in multi slice scanner.[21] In 2017, Changizi *et al*., estimated the dose of thyroid in Brain CTscan with a multi slice scanner by TLD-100 dosimeter to the 0.04 mSv.[25] This amount is similar to calculated value in this study.

Also, CTDI values of console for the applied protocols were calculated using a semiconductor detector. These values for brain scan and sinus scan were 36.18 and 9.77 mGy, respectively. Meanwhile, CTDI values on console for brain scan and sinus scan were 29.32 and 7.98 mGy, respectively. Results showed that the CTDI values calculated by semiconductor are 18.5% higher than the values indicated by the device. By putting CTDI values in ImPACT software, no change was observed in the calculated dose using this software. Therefore, it could be inferred that alteration up to 18.5% in CTDI values does not change the mean absorbed dose by thyroid gland.

Conclusion

It was shown that in measuring thyroid absorbed dose by two methods, mean dose absorbed by thyroid in brain scan are almost similar in both methods; however, mean doses absorbed by thyroid in uni-directional and bi-directional sinus scans were different in two methods of evaluating dose. Furthermore, the calculated CTDI differences of console with the amount calculated by the semiconductor detector dose not differ by 18.5% in the calculated result.

Financial support and sponsorship

None.

Conflicts of interest

There are no conflicts of interest

References

1. Ng KH, Rassiah P, Wang HB, Hambali AS, Muthuvellu P, Lee HP, *et al.* Doses to patients in routine X-ray examinations in Malaysia. Br J Radiol 1998;71:654-60.
2. Shahbazi-Gahrouei D, Ayat S. Comparison of three methods of calculation, experimental and Monte Carlo simulation in investigation of organ doses (thyroid, sternum, cervical vertebra) in radioiodine therapy. J Med Signals Sens 2012;2:149-52.
3. Shahbazi-Gahrouei D, Cheki M, Moslehi M. Assessment of organ absorbed dose in patients following bone scan with technetium-99m-labeled methylene diphosphonate (MDP) using of MIRD method. Eur J Nucl Med Mol Imaging 2013;40:S402.
4. Davies L, Welch HG. Increasing incidence of thyroid cancer in the United States, 1973-2002. JAMA 2006;295:2164-7.
5. Liu YQ, Zhang SQ, Chen WQ, Chen LL, Zhang SW, Zhang XD, *et al.* Trend of incidence and mortality on thyroid cancer in China during 2003 – 2007. Zhonghua Liu Xing Bing Xue Za Zhi 2012;33:1044-8.
6. Zeng H, Zheng R, Guo Y, Zhang S, Zou X, Wang N, *et al.*

Cancer survival in China, 2003-2005: A population-based study. Int J Cancer 2015;136:1921-30.

7. Aliasgharzadeh A, Shahbazi-Gahrouei D, Fahimeh A. Radiation cancer risk from doses to newborn infants hospitalized in neonatal intensive care units in children hospitals of Isfahan province. Int J Radiat Res 2018;16:117-22.
8. Zhu C, Zheng T, Kilfoy BA, Han X, Ma S, Ba Y, *et al.* A birth cohort analysis of the incidence of papillary thyroid cancer in the United States, 1973-2004. Thyroid 2009;19:1061-6.
9. Schonfeld SJ, Lee C, Berrington de González A. Medical exposure to radiation and thyroid cancer. Clin Oncol (R Coll Radiol) 2011;23:244-50.
10. Preston DL, Ron E, Tokuoka S, Funamoto S, Nishi N, Soda M, *et al.* Solid cancer incidence in atomic bomb survivors: 1958-1998. Radiat Res 2007;168:1-64.
11. Bouzarjomehri F, Zare MH, Shahbazi-Gahrouei D. Patient dose resulting from CT examinations in Yazd, Iran. Iran J Radiat Res 2006;4:121-7.
12. ICRP, Eckerman K, Harrison J, Menzel HG, Clement CH. ICRP publication 119: Compendium of dose coefficients based on ICRP publication 60. Ann ICRP 2012;41 Suppl 1:1-30.
13. Mazonakis M, Tzedakis A, Damilakis J, Gourtsoyiannis N. Thyroid dose from common head and neck CT examinations in children: Is there an excess risk for thyroid cancer induction? Eur Radiol 2007;17:1352-7.
14. Sadeghiany T, Malayeri B, Hashemi H, Sharafi A. Evaluation CT dose of children in conventional and quality control index in a CT scan system. Med Phys 2006;2:31.
15. Khosravi M, Shahbazi-Gahrouei D, Jabbari K, Nasri-Nasrabadi M, Baradaran-Ghahfarokhi M, Siavashpour Z, *et al.* Photoneutron contamination from an 18 MV saturne medical linear accelerator in the treatment room. Radiat Prot Dosimetry 2013;156:356-63.
16. Gu J, Dorgu A, Xu XG. Comparison of main software packages for CT dose reporting. Health Phys 2008;95:S50.
17. Sharifian S, Shahbazi-Gahrouei D. Dose assessment in multidetector computed tomography (CT) of polymethylmethacrylate (PMMA) phantom using American Association of Physicists in Medicine-Task Group Report No. 111 (AAPM-TG111). J Isfahan Med Sch 2017;35:200-5.
18. Rydberg J, Buckwalter KA, Caldemeyer KS, Phillips MD, Conces DJ Jr. Aisen AM, *et al.* Multisection CT: Scanning techniques and clinical applications. Radiographics 2000;20:1787-806.
19. Smallridge RC, Ain KB, Asa SL, Bible KC, Brierley JD, Burman KD, *et al.* American Thyroid Association guidelines for management of patients with anaplastic thyroid cancer. Thyroid 2012;22:1104-39.
20. Akpochafor MO, Omojola AD, Habeebu MY, Ezike JC, Adeneye SO, Ekpo ME, *et al*. Computed tomography organ dose determination using ImPACT simulation software: Our findings in South-West Nigeria. Eurasian J Med Oncol 2018;2:165-72.
21. Jaffe TA, Hoang JK, Yoshizumi TT, Toncheva G, Lowry C, Ravin C, *et al.* Radiation dose for routine clinical adult brain CT: Variability on different scanners at one institution. AJR Am J Roentgenol 2010;195:433-8.
22. Zammit-Maempel I, Chadwick CL, Willis SP. Radiation dose to the lens of eye and thyroid gland in paranasal sinus multislice CT. Br J Radiol 2003;76:418-20.
23. Diekmann S, Siebert E, Juran R, Roll M, Deeg W, Bauknecht HC, *et al.* Dose exposure of patients undergoing comprehensive stroke imaging by multidetector-row CT: Comparison of 320-detector row and 64-detector row CT scanners. AJNR Am J Neuroradiol 2010;31:1003-9.
24. Fujii K, Aoyama T, Yamauchi-Kawaura C, Koyama S, Yamauchi M, Ko S, *et al.* Radiation dose evaluation in 64-slice CT examinations with adult and paediatric anthropomorphic phantoms. Br J Radiol 2009;82:1010-8.
25. Changizi V, Mohammadi 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;11:532-40.

BIOGRAPHIES

Asghar Maziar Assistance Professor of Medical Physics: BSc in Radiology technology (School of Medical Sciences, Tabriz University of Medical Sciences, Tabriz, Iran, 1995), MSc in Radiology technology (Tarbiat Modarres University, Tehran, Iran, 1998), PhD in Medical Physics (Isfahan University of Medical Sciences, Isfahan, Iran, 2015).

Email: maziar.a@iums.ac.ir

Reza Paydar Assistance Professor of Medical Physics: BSc in Physics (School of physics, Science and technology university of Iran, Iran, 1999), MSc in Medical Physics (Isfahan university of medical sciences, Isfahan, Iran, 2001), PhD in Medical Physics (Tehran university of medical sciences, Tehran, Iran, 2012).

Email: paydar.r@iums.ac.ir

Ghazal Azadbakht received her BSc degree from Tehran Unuiversity, Tehran, Iran in 2007, MSc degree in Radiobiology and radiation protection from Iran University, Tehran, Iran in 2018 . Her research interest include estimate thyroid dose.

Email: ghazalazad3717@gmail.com

Daryoush Shahbazi-Gahrouei Professor of Medical Physics: BSc in Physics (School of Science, Isfahan University, Iran, 1987), MSc in Medical Physics (Tarbiat Modarres University, Tehran, Iran, 1991), PhD in Medical Physics (University of Western Sydney and St. George Cancer Care Centre, Sydney, Australia, 2000).

Email: shahbazi@med.mui.ac.ir