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Audit of computed tomography examinations from two selected radio-diagnostic centers in South-South Nigeria

Ndubuisi Ozoemena Chiaghanam[1]   Emmanuel Okon Esien-umo[1]   Michael Promise Ogolodom[2*]
Valentine Cornelius Ikamaise[1]   Archibong Bassey E[1]   Mary Ekpot[1]

[1]*Department of Radiography and Radiological Science, University of Calabar, Calabar, Cross River State, Nigeria.*
[2]*Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University Nnewi Campus, Anambra State, Nigeria.*

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ABSTRACT

Background: Despite the fact that the number of CT exams is small among all radiography investigations, a high amount of medical radiation exposure comes from CT application. Most developed nations have adopted regular audits to ensure optimization of ionizing radiations in the CT examinations, but on the contrary, it has infrequently been performed in developing countries like Nigeria.

Objectives: This study was designed to carry out an audit of CT examinations at two selected diagnostic centers in the South-South region of Nigeria.

Materials and methods: This study was a retrospective cross-sectional study conducted in two radiological facilities, which involved 210 tomographs of the chest, head, and abdomen, selected using a convenient method. The CT examinations were done using the departmental protocols and the generated data were analyzed statistically using descriptive statistics.

Results: Head examination was the most commonly performed CT examination (56.7%), followed by abdominal 28.6 % and the least 14.8% was chest. The most common indication was a road traffic accident (RTA) 11.4%. The distribution of the type of CT machine that was used for the study showed that the Toshiba machine was used for most of the subjects 132 (62.9%) followed by Optima CT660 78 (37.1%). It was seen that 48.6% of the study used 0.75s, 40.5% used 0.5s, 10.5% used 0.35s and only 0.5% used 1s scan time. The effective doses were adult head (2.31±0.14), chest (4.65±0.21), abdominal (7.70±0.17), pediatric head (2.81±0.21), and pediatric chest (9.96±0.12).

Conclusion: The carrying out of clinical audits is imperative to ensure both safeties of patients and diagnostic accuracy.

Introduction

The introduction of computed tomography (CT) scanners into diagnostic Radiology was dated back to 1970s. CT has gained attractiveness globally owing to the substantial and life-saving clinical advantages.[1] However, the increase in the use of CT application has led to the emergence of radiologic concerns such as cancer risk because of the incremental effective dose (ED) associated with its use.[2] Despite the fact that numbers of CT is small among those radiography investigations, high amount of medical radiation exposure comes from CT application.[3]

It has been documented that approximately 1-14 mSv is the radiation dose associated with a typical CT scan, and this is equivalent to the annual dose received from natural sources of radiation, such as radon and cosmic radiation (1-10 mSv), depending on the location.[4] When organ specific cancer risk was adjusted for current levels of CT usage, it

* **Corresponding author.**
Author's Address: *Department of Radiography and Radiological Sciences, Nnamdi Azikiwe University Nnewi Campus, Anambra State, Nigeria.*
** **E-mail address:** mp.ogolodom@unizik.edu.ng
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was estimated that 1.5-2% of cancer may eventually be caused by ionizing radiation used in CT.[5] This situation places an obligation on the community to review the amount of radiation set for CT scans and to improve the usefulness of the data for daily clinical practice.[6]

The ICRP recommended that medical activities involving ionizing radiation should fulfill the three basic principles of justification, optimization and dose limitation.[7-9] Therefore, proper clinical audit, practicing justification and development of optimized size specific scan protocols is important to keep the doses at an appropriate level and to reduce the risk associated with CT examination.[10] This involves taking into consideration the patient age, gender, technical parameters such as tube potential, time per rotation, detector configuration, beam collimation, pitch and effective mAs), CT Dose indicators (Volume CT Dose Index- CTDIvol and Dose Length Product-DLP), date of CT examination, sources of referrals for medical image, anatomical regions scanned, contrast agent used and route of administration.

Most developed nations has adopted regular audit to ensure optimization of ionizing radiations in the CT examinations, but on the contrary, it has infrequently been performed in developing countries like Nigeria.[11] This may have significant negative impact on the radiation doses received by patients undergoing CT investigations especially with the increasing numbers of CT scanners in our country. Hence, this study was designed to carry out an audit of CT examinations at two selected diagnostic centers in South-South region of Nigeria.

Materials and methods

This was a retrospective cross-sectional study conducted in two radiological facilities with functional CT scanners in Akwa-Ibom State and Rivers State, Nigeria. The study, which lasted for three months (May-July, 2019) involved 210 tomographs of chest, head and abdomen, selected using convenient method. Only tomographs obtained at least one month prior to this study and those with proper identification such as gender, age and date of examination were included in this study. Written permission for the collection of data was obtained from the study centers before accessing their CT archives.

The CT examinations were done using the departmental protocols, which included the scanogram and selection of specific options in operating console of the machine for the purpose of dose reduction, non-contrast axial slice at 2-5 mm thickness while slices were obtained following administration of low osmolar contrast medium (LOCM) at the dose of 300 mg/mL of the LOCM. Oral iodinated flavored contrast medium was administered for abdominal examinations, appropriate protocols was selected depending on the region of the body under examination. To further minimize the radiation dose of the patients, lead covers was applied to shield the body parts that were not under examination.

Effective dose is the only dose metric that can represent risk associated with CT examinations. A simplified method of estimating effective dose for CT examination entails multiplying the DLP value by an appropriate normalized specific k-coefficient (effective dose/DLP conversion factor). The k-coefficient is an effective dose conversion factor established by the National Radiological Protection Board (NRPB) for specific CT examinations, which take into account the patient's age and specific region being imaged.[12] The conversion factors have a wide age based range and do not take into account the patient's sex or specific scanner used and is the same for different scanners with the same parameters even though different scanners with different designs and beam filtration may produce different numbers for effective dose and DLP.[13]

The acquired images were transferred to the diagnostic workstation and were interpreted by at least one consultant radiologist. The information concerning the age, gender, and indication for CT examination were documented. The generated variables were collected using data capture sheet and analyzed statistically using descriptive statistics on SPSS version 21.

Results

Of the 210 tomographs, 113 (53.80%) were males and 97 (46.20%) females. Their age ranged from 1-78 years with a mean of 38.28±18.45 years. The grouped frequency table also showed that majority 33 (15.70%) were within the age of 35-39 years (Table 1). The most common indication for CT examination in the subjects was road traffic accident (RTA) 11.40%, followed by severe headache 9.00%, and multiple gunshot injuries (7.10%). other indications found in this study included severe cough, general body weakness, abdominal pains, abdominal swelling, jaundice, hypertensive heart disease, trauma etc. (Figure 1).

Table 1 Age group frequency distribution of the subjects.

Age groups	Frequency	Percent (%)
0-4	10	4.8
5-9	8	3.8
10-14	4	1.9
15-19	6	2.9
20-24	16	7.6
25-29	25	11.9
30-34	19	9.0
35-39	33	15.7
40-44	19	9.0
45-49	16	7.6
50-54	8	3.8
55-59	15	7.1
60-64	10	4.8
65-69	6	2.9
70-74	8	3.8
>75	7	3.3
Total	210	100.0
Gender		
Male	113	53.8
Female	97	46.2

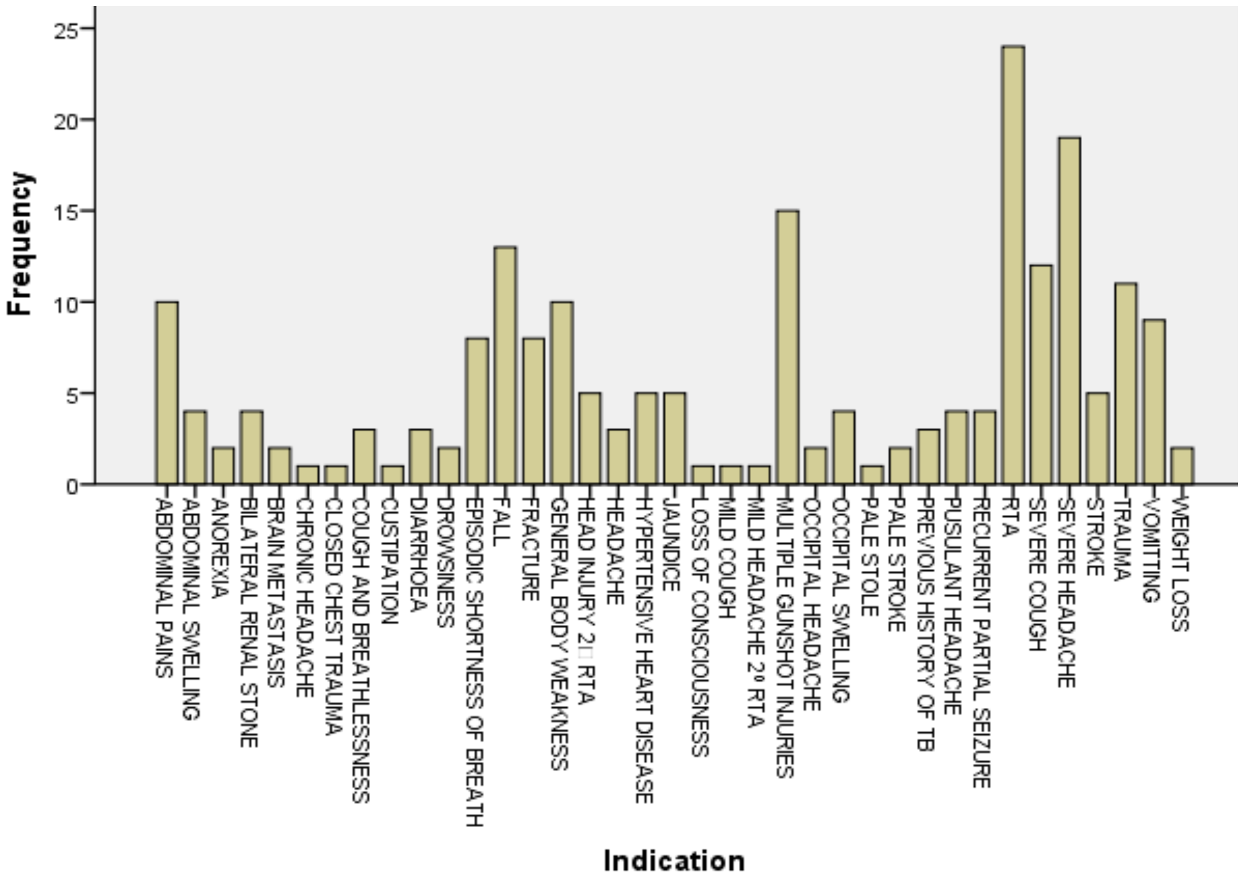

***Figure 1**. Usual indications for CT scan performed on the subjects.*

Figure 2 shows the types of CT examination performed on the subjects. Head examination was most commonly performed in 56.70% followed by abdominal CT 28.60% and the least 14.80% was Chest CT examination. The distribution of the type of CT machine that was used for the study showed that Toshiba machine was used for most of the subjects (62.90%) followed by Optima CT660 (37.10%) (Table 2). It was seen that 48.60% of the study used 0.75s, 40.50% used 0.50s, 10.50% used 0.35s and only 0.50% used 1s scan time (Table 2).

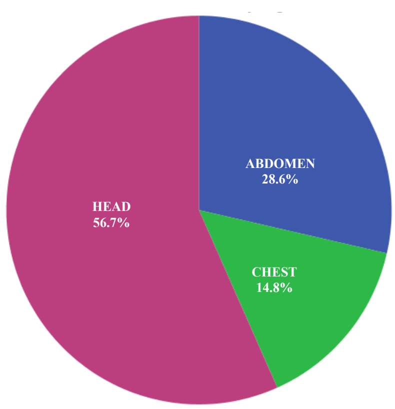

***Figure 2**. Types of CT examination performed on the subjects.*

Table 2 Cross tabulation of the scan time and machine used.

Time per rotation (sec)	CT machine		Total
	OPTIMA CT660	TOSHIBA	
0.35	11	11	22
0.50	25	60	85
0.75	42	60	102
1.00	0	1	1

Table 3 shows comparison of adult head, chest, and abdominal CT dose values with Dose Reference Level (DRL) given in the international guidelines (14-15). Group 1 (16 years and above) was imaged according to the protocols set by the Optima and Toshiba. The technical factors and radiation doses at routine adult heads, chest and abdominal is reported in table 4. Table 5 shows comparison of pediatric head, chest, and abdominal CT dose values with DRLs given in the international guidelines Group 2 (0-15 years) was imaged according to the protocols set by the Optima and Toshiba. The effective doses were adult head (2.31±0.14), chest (4.65±0.21), abdominal (7.70±0.17), pediatric head (2.81±0.21) and pediatric chest (9.96±0.12) (Table 6).

Table 3 Comparison of head, chest, and abdominal CT dose values with DRLs given in the international guidelines.

Examination	Dose parameter	Group 1	EU (2004)	IAEA (2006)
Adult head CT	CTDIvol (mGy)	53.19	60	47
	DLP (mGy.cm)	1098.6	1050	1050
Adult chest CT	CTDIvol (mGy)	7.903	30	9.5
	DLP (mGy.cm)	332.1	650	447
Adult abdominal CT	CTDIvol (mGy)	10.9	35	10.9
	DLP (mGy.cm)	513.2	780	696

Table 4 Important technical factors at routine adult heads, chest and abdominal CT examinations in the center.

Examination	Parameters	No of patients
Adult head CT		100
	Average age	43.23
	mA	127-410
	Rotation time	0.7
Adult chest CT		30
	Average age	18.0
	mA	150-480
	Rotation time	0.43
Adult abdomen CT		57
	Average age	39.98
	mA	80-480
	Rotation time	0.5

Table 5 Comparison of pediatric head, chest, and abdominal CT dose values with DRLs given in the international guidelines Group 2 (0-16 years) was imaged according to the protocols set by the Optima and Toshiba.

Examination	Parameters	Group 2	IAEA (2004)	DDM2 (2012)
Pediatric head CT	Number of patients	18		
	Average age	5.4		
	Ma	151-450		
	CTDIvol	38.3		
	DLP	669.3	600	470
	Rotation time	0.6	0.5	0.5
Pediatric chest CT	Number of patients	2		
	Average age	9		
	mA	119		
	CTDIvol	7.0		
	DLP	765.8	430	450
	Rotation time	0.35	0.5	0.5
Pediatric abdomen CT	Number of patients	3		
	Average age	10		
	mA	70-119		
	CTDIvol	3.7		
	DLP	352.3	450	475
	Rotation time	0.43	0.5	0.5

Table 6 Effective dose for adult and pediatric head, chest and abdominal CT examination.

Examination	Effective Dose (mSv)
Adult head CT	2.31±0.14
Adult chest CT	4.65±0.21
Adult abdominal CT	7.70±0.17
Pediatric head CT	2.81±0.23
Pediatric chest CT	9.96±0.12
Pediatric abdominal CT	5.28±0.22

Discussion

The purpose of this study was to perform an audit of CT examinations in diagnostic centers in South-South region of Nigeria. This was done according to the recommendations and guidelines of radiation protection report No.159, which describes how to implement a structured audit in a Radiology Department in compliance with the most recent guidelines from International Atomic Energy Agency (IAEA) (16). A total of 210 subjects including 113 males (53.8%) and 97 females (46.2%) with age ranged from 1 year to 78 years old were included in the study. Three types of examination were evaluated namely, routine head/brain CT, abdominal CT and chest CT. For each patient, demographic information (age, sex), exposure parameters like tube potential (kVp), mA, time per rotation, and dose parameters (CTDIvol and DLP) were recorded. Data was obtained from two diagnostic centers in Port Harcourt and Uyo metropolises in Nigeria.

Toshiba machine was used in 132 (62.9%) of the subjects and Optima CT660 78 (37.1%) with rotation time ranging from (0.35-1.00 sec). The DRL for the anatomical regions, head, chest and abdomen for both female and male patients were obtained. Two groups were considered (Group 1 and Group 2). Group 1 consisted of adult patients (17 year and above) who were imaged according to the protocols set by the Optima and Toshiba and Group 2 consisted of pediatrics (0-16 years) who were images according to the protocols set by Optima and Toshiba. Table 3 showed the comparison of adult head, chest and abdominal CT dose values (CTDIvol and DLP) with DRLs given in the international standard.[14-15] It was seen that the radiation for Group 1 were lower than the international guidelines. This indicates that radiation dose is kept within limits and guidelines.

The mean weighted CT dose Index CTDIvol for adult head Group 1 was (53.10 mGy) for head CT in the entire sample (female and male patients was comparable to values reported by.[19,20] The mean DLP (1098.60 mGy.cm) for head CT was higher than that of the other authors such as 740 mGy.cm,[21] 587 mGy.cm,[22] 787 mGy.cm.[23] Also, the mean weighted CT dose index for adult abdominal CT (Group 1) was 10.9 mGy, which is in the range of values (10-29 mGy) reported by.[19,24,25] The mean DLP for abdominal CT (513.2 mGy.cm) was lower than the values reported by (25) (493-551 mGy.cm). Moreover, the mean weighted CT dose index (7.9 mGy) for chest CT was lower than the value reported in the previous IAEA coordinated research project (16.20 mGy).[23] The mean DLP (33.20 mGy.cm) for chest CT was lower than the IAEA reported value 455 mGy.cm.[26]

Table 5 showed the comparison of pediatric head and chest dose values (CTDIvol and DLP) with DRLs given in the international standard.[14,16,18] It was seen that the CTDIvol for group 2 were much lower than the international guidelines and the DLP were much higher than that of the international guidelines. The mean weight CT dose index CTDIvol for pediatric head was (38.3mGy.cm) for age 5 yrs. This variation may be as a consequence of differences in CT scanner design and examination protocols.[12]

The mean DLP value of 669.3 mGy.cm for pediatric head CT was higher than the ones reported by IAEA (600 mGy.cm)[15] and Dose Datamed 2 Project- DDM2 (47 0 mGy.cm).[18] Also the mean CTDIvol for pediatric chest CT was (7.00 mGy.cm) which was in range of values reported by Klang *et al*.[2] The mean DLP for pediatric chest CT (765.80 mGy.cm) was higher than 368 mGy.cm reported by DDM2.[18] However, the mean DLP for pediatric Abdominal CT (age 10) of 352.30 mGy.cm was lower than the values reported by IAEA, which was 450 mGy.cm. These differences in our findings could be attributed to scanners having varying number of detector rows and different brand have specific manufacturer detector configuration and dose compensation mechanism that respond to exposure contrarily from each other and thus produce dissimilar doses.[12]

It was seen that the effective dose for adult head CT examination was 2.31 mSv, adult chest CT was 4.65 mSv, and adult abdomen CT was 7.70 mSv. Also, the effective dose for pediatric head, chest and abdomen CT were 2.81 mSv, 9.96 mSv and 5.28 mSv respectively. According to Ploussi and Efstathopoulos a typical head CT scan which is the most frequent CT examination in adults and children delivers an effective dose of about 4 mSv.[28] Whereas the effective doses for the abdomen and coronary angiography CT examinations can reach 25 mSv and 32 mSv, respectively. Thus, as far as radiation risk effects are concern, radiation exposure from the studied CT examinations were far below the threshold.

Conclusion

Carrying out of clinical audits is imperative to ensure both safety of patients and diagnostic accuracy. Comparing the Local DRLs and the calculated effective doses with that of the international standards produced comparable safe results though with variations, which may be attributed to differences in CT scanner design and examination protocols.

Conflict interest

None declared among the authors.

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References

[1] Mettler F, Bhargavan M, Faulkner K., Giller D, Gray J, Ibbott G. Frequency, Radiation dose and comparison with other radiation sources. Radiol Society North Am (RSNA). 2009; 259: 520-31.

[2] Aydin P, Gokce K, Tolga I, Emine B, Figen B, Tolga O, Sadi G. Patient doses from CT examination in Turkey. Diagn Interventional Radiol J. 2015; 21: 428-34.

[3] Elliot A. (2009). Issues in Medical exposure. J Radiol. 2009; 29: 107-21.

[4] Chiaghanam NO, Nzotta CC, Enweani IB (2019) Radiation Risk Assessment of Soil in Idomi, Cross River State, Nigeria. Asian J Appl Sci. 2019; 7(1): 27-35.

[5] Brenner D, Hall E. Computed Tomography-An increasing source of radiation exposure. American J Radiol. 2007; 357(2): 2277-84.

[6] Chanda R, Bwanga O, Sindaza N, Mercy NC, Chisha M (2020) Audit of completion of Computed Tomography (CT) request forms at the Cancer disease hospital (CDH) of Zambia. Med J Zambia. 2020; 47(4): 289-96.

[7] Chiaghanam NO, Nwoyi IE. Paediatric entrance surface doses in routine X-ray examinations in three radiology facilities within South-South, Nigeria. Sci Technol. 2020; 6: 12-9.

[8] Chiaghanam NO, Esien-umo EO, Egbe NO, Asuquo CF, Akpanama D.P (2022a) Efficacy of shielding structure in Computed Tomography Suite in selected radiodiagnostic centres in Uyo metropolis Akwa Ibom state Nigeria. Inter J Sci and Engineering Res. 2022b; 13(3): 215-33.

[9] Chiaghanam NO, Esien-umo E, Ogolodom MP, Asuquo C, Maurice C, Omita E, Ugwuanyi DC, Ezugwu EE. Safety of Ionizing Radiation in selected Conventional X-ray Diagnostic centres in Calabar and Uyo metropolises, Nigeria. Euro Sci J. 2022b; 18(21): 1-9.

[10] Ogbole GI, Obed R. Ra diation dose in computed Tomography: Need for optimization and application of dose reference levels in Nigeria. West Afri J Radiol. 2004; 21(1):1-16.

[11] Liang CR, Chen PXH, Kapor J, Ong MKL, Quek ST, Kapor SC. Establishment of Institutional diagnostic reference level for CT with automated tracking software. J Med Radiat Sci. 2017; (64): 82-9.

[12] Small R., Surujpaul P.P, Chakraborty S. (2019) Patient Dose Audit in Computed Tomography at Cancer Institute of Guyana. J Med Diagn Meth. 2019; 18 (1): 1-13.

[13] Newman B, GangulyA, Kim JE, Robinson T. Comparison of different methods of calculating CT radiation effective dose in children. AJR Am J Roentgenol. 2012: 199: W232-W9.

[14] European Union. European Commission guidelines on clinical audit from medical radiological practice. Publication 159. 2004.

[15] International Atomic Energy Agency. Optimization of the radiological protection of patients undergoing radiography, fluoroscopy and computed tomography. Annals of IAEA coordinated research project. Austria. 2004.

[16] International Atomic Energy Agency. Dosimetry in Diagnostic Radiology for pediatric patients. Human Health Series-IAEA no. 24. 2013.

[17] Bongartz G, Golding S, Jurik A, Leonardi, M. Van Persijn. Quality criteria for multislcie computed tomography. Results from a European concerted action on CT (FIGM-CT-2000-20078) Appendix B. European Field Survey on MSCT. 2004.

[18] DDM2. Study on European population doses from medical exposure. 2012.

[19] Friberg E, Borretzen I, Olerud M. Dual and Multidetector row CT: what about the doses?" presented at the Radiation protection symposium of the Northwest European Radiation Protection societies, Utrecht, the Netherlands. 2003.

[20] Foly, S., McEntee, M., Rainford L. Establishment of CT diagnostic reference levels in Ireland. British J Radiol. 2012; 85: 1390-7.

[21] Prokop M, Galanski M. Spiral and multislice computed tomography of the body. Thieme, New York, NY. 2003; p. 133-60.

[22] Hidajat N, Wolf M, Nunnemann A, Liersch P, Gebauer B. Survey of conventional and spiral CT doses. J Radiol. 2001; 218: 395-40.

[23] Shrimpton P, Hillier M, Lewes M, Dunn M. National Radiological Protection Board (NRPB): doses from Computed Tomography examinations in the UK-2003 review. Document NRPB-W67. Chilton England. 2005.

[24] Shrimpton, P., Hillier, M., Lewis, M., Dunn, M. National survey of doses from CT in the UK: 2003. British J Radiol. 2006; 79: 768-980.

[25] Papadimitrious D, Perris A, Maneton A, Molfetas M, Panagiotakis N. A survey on 14 computed tomography scanners in Greece and 32 scanners in Italy. Examination frequencies, dose reference values, effective doses and doses to organs. J Radiat Protect Dosimetry. 2003; 104: 47-53.

[26] Tsapaki V, Aldrich J, Sharma R, Staniszewska M, Krisanachinda A. Dose reduction in CT while maintaining diagnostic confidence: Diagnostic dose reference levels at routine head, chest and abdominal CT- IAEA- coordinated research project. 2006; 240: 828-34.

[27] Klang E., Beytelman A., Greenberg D., Or J., Zimlichman E. Overuse of Head CT examinations for the investigation of minor head truma: Analysis contributing factor. J Am Coll Radiol. 2017; 14(2): 171-6.

[28] Ploussi A, Efstathopoulos P E. Importance of establishing protection culture in radiology department. World J Radiol. 2016; 8: 142-7.