Diagnostic Reference Levels of Radiographic and CT Examinations in Jordan: A systematic Review

A comprehensive search was done to examine the literature on the diagnostic reference level (DRL) for computed tomography (CT) and radiographic tests that are currently used in Jordan. EBSCO, Scopus, and Web of Science were used for the search. 7 papers that reported DRL values for radiography and CT scans in Jordan were found in the search. One study reported the DLRs for conventional radiography. Two of those studies reported the CT DRLs in children and the remaining studies (n=4) provided DRL values for adults CT scans. The most popular techniques for determining the DRLs were the entrance surface dose, volume CT dose index (CTDIvol), and dose-length product (DLP). Variation in the Jordan DRL values were noted. Lower patient doses and less variation in DRL values may be achieved by educating and training radiographers to better understand dose reduction strategies.

Implications for practice: To limit dose variance and enable dosage comparison, CT DRLs must be standardized in accordance with the guidelines of the International Commission on Radiological Protection.

Introduction

Increased knowledge of the hazards of ionizing radiation has led to the need for radiation dose assessment of patients during diagnostic X-ray examinations. Investigating areas that require dose reduction might be aided by illustrating patient dose fluctuations and their causes [1, 2].

In 1996, the International Commission on Radiological Protection (ICRP) Publication 73 introduced diagnostic reference level (DRL) values (3). However, a few years before, the notion of designating an exploratory level for typical radiography operations had been floated. A DRL is an "investigation level used to aid in optimizing protection in the medical exposure of patients for diagnostic and interventional procedures," according to the commission's definition (4). Since its introduction, the idea behind DRLs has undergone numerous developments. The DRL, on the other hand, was never meant to be a dose limit but rather a dose standard developed from data for examinations of particular age groups and forms. DRL values assist in identifying procedures that subject patients to radiation doses over the permitted levels at the national or international levels. DRL readings below these ranges, however, can point to the acquisition of images with inadequate image quality for diagnosis. This can be useful in identifying improper procedures used in imaging tests that subject patients to excessive radiation doses. However, a significant shortcoming of DRL is its inability to provide details on the degrees of image quality for radiography and computed tomography (CT) scans, which is a crucial step in the diagnostic procedure.

The entrance surface dose (ESD) and dose area product (DAP), incorporating the contribution of backscatter radiation, are frequently used to set DRL values for radiography examinations. The ICRP advises utilizing both measurements to ensure that the impact of the radiation beam size is assessed (4). The imaging device provides the DAP values, which are calculated as the product of the radiation beam's area times its intensity. The ESD can be calculated theoretically utilizing the imaging parameters, such as the source-to-skin distance, the X-ray tube peak kilovoltage, and radiation dosemeters that do not interfere with the X-ray images. The CT dose index (CTDI), which is a measurement of dose from a single rotation of the gantry, is where the amounts that are usually utilized to determine the DRL values for CT exams come from (5).

The average absorbed dose inside the scanned volume is known as the volume CTDI (CTDIvol), and it is frequently used to calculate DRL values. It used to be more common to utilize the weighted CTDI (CTDlw), which is the weighted average of two measured CTDI values. The dose-length product (DLP), which takes into account the length of the scan to predict the amount of radiation that patients will absorb, is another parameter that is widely used for setting DRL for CT exams. Recently, it has been suggested that the size-specific dose estimate (SSDE) be used to calculate DRL values for CT exams in order to get around the fact that none of these numbers take into account the variations in patient sizes and shapes. The aim of this review is to explore the literature on the existing DRL values of radiographic and CT examinations in Jordan.

METHOD

Using Web of Science and databases including Medline, ScienceDirect, Scopus, and EBSCO, as well as CINAHL, a comprehensive search was carried out. The medical subject heading (MeSH) phrases were used to find the term "diagnostic reference levels." The acronym "DRL" and the additional phrases, "dose reference levels," were used to search for articles in literature that was pertinent but not listed on MeSH. The phrase "Saudi Arabia" was used to focus the search on articles that reported DRL values of radiography and CT tests in Saudi Arabia. Additionally, only publications that had been published in peer-reviewed journals and in English were included in the search. The preferred reporting items for systematic reviews and meta-analyses (PRISMA) were the foundation for the search, which was carried out in June 2023 (Figure 1) (6). The papers were manually screened in two stages: first, the titles and abstracts were used to weed out studies that weren't relevant; second, the qualifying articles were thoroughly examined to make sure they satisfied the inclusion criteria.

RESULTS

The search identified 7 studies that reported DRL values for radiographic and CT examinations in Jordan. The first DRL values of radiographic and CT examinations in Jordan were published in 2019 and 2018 respectively.

one study that included 100 patients and exams utilizing computed radiography from three major public hospitals in northern Jordan (KA, PB and PR). DRL values for chest PA, abdomen AP radiography were published. The adults were 20 patients from each of KA and PB hospitals, with 10 patients for each examination. The 60 children involved in this study were from PR hospital; the children were classified into three groups based on their ages: 0–1, 1–5, and 5–10 y. The values used in this research were derived from measurements of the ESDs, which were obtained directly using thermoluminescent dosimeters (TLD) and effective dose (ED) was reported in this study (7) which was calculated using PCXMC program for dose calculations.

Table 1 shows the DRL ED values for radiographic examinations in Jordan.

Hospital	Examination	Age (y) Mean (min-max)	ESD (mGy) Mean (min-max)	ED (µSv) Mean (min-max)
			Adults	
KA	**Chest**	45 (25–66)	0.49 (0.42-0.630)	43 (37–51)
	Abdomen	34 (18–73)	12.94 (8.26-16.25)	1,420 (811–1,847)
PB	**Chest**	48 (27–69)	0.35(0.20-0.830)	30 (19–63)
	Abdomen	26 (24–28)	2.23(0.97-3.930)	208 (98–396)
			Children	
PR	**Chest**	0.6 (0–1)	0.131(0.08-0.190)	18 (1–30)
		2 (1–5)	0.136(0.05-0.170	14 (7–20)
		9 (5–10)	0.191(0.12-0.310	17 (10–35)
	Abdomen	0.4 (0–1)	0.198(0.15-0.270	30 (20–36)
		2 (1–5)	0.140(0.08-0.170	18 (9–24)
		11 (5–10)	0.225(0.15-0.270)	21 (18–24)

Table 1. Distribution value of ESDs mean (minimum [min], maximum [max]), and mean EDs mean (min-max) for chest (PA) and abdomen (AP) examination for adults and different age groups of children.

The DRL values for CT examinations were reported in 6 studies, two from these studied were report the DRL in pediatric (8-9), one reported the DRL in cardiac CT (10), one reported the DRL for renal CT (11) and the last two were reported the chest, abdomen, pelvis, brain CT (12-13). All studies determined the DRL values of the CT scans using patient data. Multiple techniques were employed to determine the DRLs for the studies that reported DRL values for CT scans. The two most often used measurements for determining DRL were the CTDIvol and the DLP. One study included the effective dose (11) and other study included the SSDE as additional measurements. The DRLs were typically calculated using the means, medians, and third quartiles

Table 2. Summary of the studies that reported DRL values for pediatric CT examinations.

Authors	Year	Study design	Sample size	Examination	Age group (year)	DRL						Unit
						CTDIvol		DLP		SSDE		
						Median	75th	Median	75th	Median	75th	
Rawashdeh et al. [8]	2019	Patients	1818	Brain	<1	47.1	47.8	644.8	743.7	-		-
					1-4	51.0	54.7	874.9	981.8	-		
					5-10	58.8	65.0	1038.4	1129.5	-		
					11-18	52.1	60.7	1097.5	1207.9	-		
				Chest	<1	5.6	5.6	86.1	124.0	-		
					1-4	4.7	7.3	104.6	222.1	-		
					5-10	5.4	12.9	252.0	416.4	-		
					11-18	12.8	12.9	262.6	496.4	-		
				Abdominopelvic	<1	6.9	12.6	145.8	325.1	-		
					1-4	9.7	19.8	294.2	408.7	-		
					5-10	9.7	12.8	336.5	460.5	-		
					11-18	12.9	16.1	612.5	807.0	-		
				Chest, abdomen, pelvis	<1	9.7	16.1	248.4	526.8	-		
					1-4	12.2	16.1	530.0	762.7	-		
					5-10	9.7	12.9	524.0	759.0	-		
					11-18	7.7	16.1	373.4	808.8	-		

Rawashdeh et al.[9]	2023	Patient	1818	Brain	<1	47.87	47.88	644.82	741.67	54.09	58.40	mGy* mGy. cm
					1-4	51.7	54.79	874.98	979.12	53.14	55.88	
					5-10	58.8	65.03	1038.44	1129.94	52.92	55.92	
					11-18	52.1	60.7	1019.1	1207.9	36.90	41.81	
				Chest	<1	5.63	5.65	86.1	124	13.90	13.91	
					1-4	4.7	7.37	104.66	220.85	9.45	14.68	
					5-10	5.41	12.57	252	383.9	9.62	22.45	
					11-18	12.89	12.94	262.65	496.2	17.65	20.49	
				Abdominopelvic	<1	6.94	12.65	145.8	321.5	15.41	28.72	
					1-4	9.7	16.16	294.2	424.72	18.86	32.68	
					5-10	9.7	12.34	336.5	450.75	17.848	22.23	
					11-18	13.12	16.13	612.5	803.07	19.11	23.06	
				Chest, abdomen, pelvis	<1	9.7	16.12	248.48	507.72	23.13	38.04	

					1-4	12.25	16.13	530.06	742.1	24.77	33.54	
					5-10	9.7	13.46	524	748.85	18.52	25.69	
					11-18	16.12	16.13	876.3	1101.5	21.29	23.85	

- The units for CTDvol and DLP respectively

Table 3. Summary of the studies that reported DRL values for adult CT examinations.

Authors	Year	Study design	Sample size	Examination	Method	Values	DRL	Unit
Rawashdeh et al. [10]	2019	Patients	228	CCT*	CTDI vol	Median -75th	31.93 -47.74	-
					DLP		727.0-1035.0	-
Rawashdeh et al. [11]	2022	Patients	1418	Renal CT	CTDI vol	Median -75th	14.07-16.15	-
					DLP		728.17-851.77	-
Radaideh et al. [12]	2023	patients	2000	CAP***	CTDI vol	Median -75th	13.9-19.3	mGy
					DLP		913-1150	mGy.cm
					ED		13.6-17.2	mSv
				AP****	CTDI vol	Median -75th	13.2-17.8	mGy
					DLP		686-923	mGy.cm
					ED		10.2-13.8	mSv
				Head	CTDI vol	Median -75th	51.9-64.3	mGy
					DLP		1114-1223	mGy.cm
					ED		2.5-2.8	mSv
				Chest	CTDI vol	Median -75th	12.86-16.6	mGy
					DLP		453-583	mGy.cm
					ED		6.37-8.1	mSv

Al Ewaidat et al. [13]	2018	patients	-	Abdomen	CTDI vol	Mean**	13.41,18.44,19.42	mGy
					DLP	Mean**	588.1,717.21,820.70	mGy.cm
				Chest	CTDI vol	Mean**	11.65,15.53,17.11	mGy
					DLP	Mean**	494.84,591.84,697.65	mGy.cm
				Brain	CTDI vol	Mean**	64.96,70.2,75.0	mGy
					DLP	Mean**	1117.99,1196.94,1313.26	mGy.cm

*CCT: cardiac CT

** the mean DRL for 16, 32, 64 CT slices respectively.

*** CAP: chest, abdomen, pelvis CT

**** AP: abdomen, pelvis CT

- Not mentioned

Discussion

DRL methodologies for common radiography and CT examinations as reported in the literature have been systematically reviewed. There was one study that mentioned the DLRs for radiographic examinations in pediatric and adults which masks the comparison within the studies difficult. It should be note that in this study the DLRs reported in terms of number of hospitals. For both chest and abdomen exams, significant variability was seen in the exposure parameters kVp and mAs as well as FSD focus to skin distance. This could result in significant differences in ESDs for the same evaluation between and within facilities. The DLRs were measured in ESD and ED and reported for chest and abdomen. The values of ESD for adult's chest were 0.49 and 0.35 in KA and PB hospitals respectively. These results appear higher europium commotion EC 1996 and IAEA 1996 (0.3 and 0.4 respectively) (15-16). Moreover, these results appear to be higher (three to forth duple) than the 2012 DRL values for the United Kingdom (17) and the 2019 DRL values for Greece (18), both of which were reported to be 0.12 mGy when compared to the DRL values for chest X-rays that were reported from other nations. The values of ESD for adult's abdomen were 12.94 and 2.23 in KA and PB hospitals respectively.

The authors attributes this to variations in the patient's size and weight. The diagnostic reference levels employ standard patient and phantom sizes with AP trunk thickness of 20 cm, and weights are typically approximately 70 kg (19). Since patients were chosen without regard to age or weight, the average patient weight in this study is 95 kg.

In regard to the children DRLs the resulting ESDs to the patients demonstrated a reasonable trend with patient age; children in the 5–10 yr age group received the highest mean ESDs of 0.225 mGy and 0.191 mGy for abdomen and chest examinations, respectively, while children in the 0–1 yr age group received the lowest mean ESDs of 0.198 and 0.131 mGy for abdomen and chest examinations, respectively. These results show that the mean ESDs (mGy) for chest PA radiography are higher for all age groups when compared with similar international studies (20-23).

The mean effective doses to adult patients in this investigation ranged from 19 µSv to 63 µSv in the chest examination and from 98 µSv to 1,847 µSv in the abdominal examination. The mean effective dosages for pediatric patients, however, ranged from 1 µSv to 36 µSv for all age categories. Effective doses for adults in chest and abdomen exams fell within the reference ranges provided by the European Communities (24) and other international publication (25). However, the mean effective dosages from the chest and abdomen examinations of pediatric patients across all age groups were generally lower than the values published in international publications (20, 22, 26, 27).

Established adult DRLs for brain, chest and abdominal CT examinations were also reviewed. The established CT DRLs were based on CTDI vol and DLP as presented in Table 3. In regard of established pediatric CT DRLs one study mention the SSDE as extra measurement. Since the majority of scanners nowadays are multi-slice devices with helical programming that includes pitch in the quantification of the dosage output for a particular protocol, the CTDIvol was mentioned in all studies (14). The most often reported dose metrics identified in this analysis are CTDI (CTDIvol) and DLP, which are the recommended dose indices for CT DRLs by ICRP and the European Commission (28-29). These indices are easily documented because they are visible on the CT scanner's control console. In contrast to SSDE and ED, which need additional computations from CTDIvol and DLP, respectively, they also require no additional analysis or computation.

Additionally, there was a considerable difference in the DRL values of the CT exams that were carried out in Jordan. There were limited studies that deal with DRLs in Jordan and the there were differences in examinations that included between the studies which makes the comparison difficult between the studies that done in Jordan. When looking to literature almost the studies that reported the DRLs were reported in mean which add extra difficulty in comparison between the international studies. The investigations by Al Ewaidat et al. (13) reported DRL values for brain , chest and abdomen, and utilizing the mean CTDLvol and DLP for establishing the values. According to this study, the mean values were reported for different CT slices number. This makes the comparison within the other studies difficult.

The rest of the studies reported the same quantities values of CTDIvol and DLP (median and 75^{th}) but for different body Parts (10-12). The median - 75^{th} CTDI vol for adult chest was 12.86-16m Gy and the DLP was 453-583mGy.cm (12). And for chest abdomen pelvis the CTDIvol-75^{th} were

13.9-19 mGy while 913-1150 m.Gy.cm for DLP. The CTDIvol- 75th in CCT were 31.93 -47.74 m Gy (10). when compared this with the study done by Alhailiy et al from Sudia Araba as a Arab country these values slightly lower (73- 43 m Gy) (30). And 727.0-1035.0 m Gy.cm for DLP (10) which is higher than these value in the by Alhailiy et al study.

Variation in DRL figures is commonly anticipated, and there has previously been an effort for standardizing the process for calculating the DRL values. The American Association of Physicists in Medicine (AAPM) has suggested utilizing SSDEs to determine the DRL values of CT examinations since this unit can get over the problem with CTDIvol, which is that it doesn't take differences in human body proportions into account (31-32). In recent years, it has become more and more common to base DRL values on SSDEs. However, DRL values based on SSDEs have only been published in one study in Jordan for pediatric CT (9). Rawashdeh et al. reported the value CTDI vol and 75th for different age groups <1 ,1-4,5-10,11-18 for brain, chest, abdominopelvic and chest abdomen pelvis examinations. The SSDEs value for median and 75th in chest for 11-18 age group was 17.65 and 20.49. Since SSDE is not frequently used and there is few research that have reported these values, it is challenging to compare the findings from this study with those from other, published studies. Furthermore, Rawashdeh et al. (9), used pediatric patient.

Conclusion

The DRL values of radiography and CT tests in Jordan have been published in a limited number of research. The comparison of reported DRL values are difficult with other DRL values in the literature. Because of the various methodologies used to determine them and the various imaging modalities used to acquire radiographic and CT images, observation of the Jordan DRL values reveals that there are significant variances in these values. These variations could be due to the variation in body size of patients involved in the studies and due to the variations of the selected exposure parameters kVp, mAs, and FSD. This indicates the opportunity to optimize exposure parameters. Through appropriate instruction and training, radiographers can become more knowledgeable about dose-minimizing methods and dramatically lessen variability in DRL readings.

References

1. Shrimpton PC, Wall BF, Jones DG, et al. Doses to patients from routine diagnostic X-ray examina- tions in England. Br J Radiol 1986;59:749±58.
2. Physical Sciences in Medicine, National Radiological Protection Board and the College of Radiographers. National protocol for patient dose measurements in diagnostic radiology. Chilton, Didcot: NRPB, 1992.
3. ICRP. Radiological Protection and Safety in Medicine [Internet]. Vol. **26**. Annals of the ICRP; 1996. Available from: http://sdl.edu.sa/middleware/Default.aspx?USESDL=true&PublisherID=AllPublishers&BookURL=https://sdl.idm.oclc.org/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edseul&AN=edseul.3000077737419&site=eds-live.
4. ICRP. ICRP Publication 135: Diagnostic Reference Levels in Medical Imaging. Annals of the ICRP; 2017. Available from: http://sdl.edu.sa/middleware/Default.aspx?USESDL=true&PublisherID=AllPublishers&BookURL=https://sdl.idm.oclc.org/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=rzh&AN=125907806&site=eds-live.
5. Allisy-Roberts P, Williams J. *Computed tomography*. In: Allisy-Roberts P, Williams JBT-FP for MI (Second E), Ed. Farr's Physics for Medical Imaging [Internet]. 2nd ed. Edinburgh, UK: W.B. Saunders; 2008. pp. 103–19. Available from: https://www.sciencedirect.com/science/article/pii/B9780702028441500119
6. Page, M. J. *et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews*. BMJ [Internet]. **372**, n71. Available from (2021). http://www.bmj.com/content/372/bmj.n71.abstract
7. Ababneh ZQ, Ababneh AM, Hani MS, Ababneh RS, Aljarrah KM. Assessment of patient radiation dose during conventional diagnostic x-ray examinations in three public hospitals in Northern Jordan using TLDs. Health Physics. 2020 Jun 1;118(6):593-9.
8. Rawashdeh M, Abdelrahman M, Zaitoun M, Saade C, Alewaidat H, McEntee MF. Diagnostic reference levels for paediatric CT in Jordan. Journal of Radiological Protection. 2019 Nov 6;39(4):1060.
9. Rawashdeh M, Saade C, Al Mousa DS, Abdelrahman M, Kumar P, McEntee M. A new approach to dose reference levels in pediatric CT: Age and size-specific dose estimation. Radiation Physics and Chemistry. 2023 Apr 1;205:110698.
10. Rawashdeh M, Saade C, Zaitoun M, Abdelrahman M, Brennan P, Alewaidat H, McEntee MF. Establishment of diagnostic reference levels in cardiac computed tomography. Journal of applied clinical medical physics. 2019 Oct;20(10):181-6.
11. Rawashdeh M, Saade C. Establishment of diagnostic reference levels in low-dose renal computed tomography. Acta Radiologica. 2023 Feb;64(2):829-36.

12. Radaideh K, Al-Radaideh A, Ramli RM, Saleh A, Alshayeb R. Establishment of national diagnostic dose reference levels (DRLs) for routine computed tomography examinations in Jordan. Polish Journal of Medical Physics and Engineering. 2023 Feb 1;29(1):26-34.
13. Al Ewaidat H, Zheng X, Khader Y, Abdelrahman M, Alhasan MK, Rawashdeh MA, Al Mousa DS, Alawneh KZ. Assessment of radiation dose and image quality of multidetector computed tomography. Iranian Journal of Radiology. 2018 Jul;15(3):1-1.
14. McCollough Leng S, Yu L, Cody DD, Boone JM, McNitt-Gray MF. CT dose index and patient dose 2011;259(2):6.
15. European Commission. European guidelines on quality criteria for diagnostic radiographic images in paediatrics. Luxembourg: European Commission; EUR 16261 EN; 1996
16. International Atomic Energy Agency. International basic safety standards protection against ionizing radiation and for the safety of radiation sources. Vienna: IAEA; Safety Series 115; 1996.
17. Hart D, Hillier M, Shrimpton P. Doses to Patients from Radiographic and Fluoroscopic X-ray Imaging Procedures in the UK—2010 Review [Internet]. Health Protection Agency. 2012. Available from: http://schola r.google.com/scholar?hl=en&btnG=Search&q=intitle: Doses+to+Patients+from+Radiographic+and+Fluo roscopic+X-ray+Imaging+Procedures+in+the+U K+–+2010+Review#5%5Cnhttp://scholar. google.com/scholar?hl=en&btnG=Search&q=intitle: HPA-RPD-029—doses+to+pat. Metaxas, V. I., Messaris, G. A., Lekatou, A. N., Petsas,
18. T. G. and Panayiotakis, G. S. Patient doses in common diagnostic X-ray examinations. Radiat. Prot. Dosim. 184(1), 12–27 (2019).
19. European Commission. European guidelines on quality criteria for diagnostic radiographic images. Luxembourg: European Commission; EUR 16260 EN; 1996
20. Atalabi OM, Bidemi IA, Adekanmi AJ, Samuel OA. Entrance surface dose from pediatric diagnostic x-ray examinations in a developing world setting: are we “ALARA principle” compliant? Br J Medicine Med Res 3:2288–2298; 2013.
21. de Azevedo ACP, Osibote AO, Boechat MCB. Survey of doses and frequency of x-ray examinations on children at the intensive care unit of a large reference pediatric hospital. Applied Radiat Isotopes 64:1637–1642; 2006.
22. Kiljunen T, Tietäväinen A, Parviainen T, Viitala A, Kortesniemi M. Organ doses and effective doses in pediatric radiography: patient-dose survey in Finland. Acta Radiologica 50: 114–124; 2009.
23. Ribeiro LA, Yoshimura EM. Entrance surface dose measurements in pediatric radiological examinations. Radiat Meas 43:972–976; 2008.
24. European Commission. European guidance on estimating population doses from medical x-ray procedures. Luxembourg: European Commission; Radiation Protection 154; 2008: 90–96.
25. Muhogora WE, Ahmed NA, Almosabihi A, Alsuwaidi JS, Beganovic A, Ciraj-Bjelac O, Kabuya FK, Krisanachinda A, Milakovic M, Mukwada G. Patient doses in radiographic examinations in 12 countries inAsia, Africa, and Eastern

Europe:

26. HudaW, Gkanatsios NA, Botash RJ, Botash AS. Pediatric effective doses in diagnostic radiology. In: 44th annual scientific meeting of Canadian Organization of Medical Physicists; London, Ontario, Canada [online]. 1998: 114–116. Available at http://nersp.nerdc.ufl.edu/~nikos/Downloads/COMP98.pdf. Accessed 27 February 2019.
27. Olgar T, Sahmaran T. Establishment of radiation doses for pediatric x-ray examinations in a large pediatric hospital in Turkey. Radiat Protect Dosim 176:302–308; 2017.
28. ICRP. Diagnostic reference levels in medical imaging. ICRP PUBLICATION 135. Ann ICRP 2017;46(1) [cited 2018 Oct 29]. Available from: http://www.icrp.org/docs/C3WPDRL.pdf.
29. European Commission. Diagnostic reference levels in thrity-six (36) European countries. RP180 part2.pdf. 2014 [Internet] [cited 2018 Oct 15]. Available from: https://ec.europa.eu/energy/sites/ener/files/documents/RP180%20part2.pdf.
30. Alhailiy AB, Kench PL, McEntee MF, Brennan PC, Ryan EA. Establishing diagnostic reference lev- els for cardiac computed tomography angiography in Saudi Arabia. Radiat Prot Dosimetry. 181(2), 129–34 (2017).
31. American Association of Physicits in Medicine. Size- Specific Dose Estimates (SSDE) in Pediatric and Adults Body CT Examinations. AAPM Report No. 204. (Col- lege Park, MD) (2011).
32. Christner, J. A., Braun, N. N., Jacobsen, M. C., Carter, R. E., Kofler, J. M. and McCollough, C. H. Size-specific dose estimates for adult patients at CT of the torso. Radiology 265(3), 841–847 (2012).