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A Review on Diagnostic Reference Levels for Adult Patients Undergoing Chest (Coronary Angiography) Computed Tomography Scan in North-East India

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Abstract

In the radiological department, the computed tomography (CT) scan process has become a greater radiation dosage that contributes to all medical X-ray treatments. Many studies throughout the world have found that CT accounts for just 5% of all operations conducted yet accounts for 34% of yearly radiation exposures in all medical X-ray treatments. Similarly, other studies have found that CT accounts for 17% of all operations conducted worldwide but accounts for 49% of total yearly doses in all medical X-ray treatments. Because diagnostic reference levels (DRLs) are one of the ways of optimizing a dose in a CT procedure, the goal of this review is to provide a DRLs for adults who undergo chest and abdomen CT scan examinations in northern India, based on research for this region and comparing with international values to see if better optimization protocol is being practiced. DRLs for the chest are 18.35mGy for CT dose index volume (CTDIvol) and 765 mGy.cm for dose length product (DLP), according to this review, while DRLs for the abdomen are 18.25 mGy and 1870.75 mGy.cm for CTDI (vol) and DLP, respectively. As a result, all of the DRLs examined had greater values than the international values compared, with the exception of CTDI (vol) of International Commission on Radiological Protection 2007 publications. CT technology is in desperate need of an update. In the northern region, optimizing methods, including exposure and technical parameter selection, should reduce dose fluctuations.

Keywords: Computed tomography dose index volume and dose length product, Computed tomography scan, Diagnostic reference levels

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Introduction

Diagnostic reference levels (DRLs) are dosage levels used in medical radiology for typical exams of groups of standard-sized individuals or a standard phantom, as well as generally specified types of equipment. When excellent and regular practice for diagnostic and technical performance is used, these thresholds are not likely to be surpassed for standard procedures (European Commission, 1999).[1] The rationale for establishing national DRLs, as stated in an International Atomic Energy Agency document titled Radiation Protection in Patients, emphasized the need for optimization, i.e., keeping all computed tomography (CT) doses as low as reasonably achievable within clinical ranges, because surveys of CT dose estimates have revealed significant variations in practice for the same patient categories in age and size, who have undergone identical types of exams. The significance of establishing DRLs cannot be overstated; nevertheless, it is important to note that DRLs are not universal, but rather country-specific. DRLs set for one nation (with varied CT practice and technology) may not be totally relevant to the conditions of another country because of differences in equipment and human training (Ogbole and Obed, 2014 and Olowookere *et al*., 2012).[2] When determining the DRL or comparing one practice to another, iterative reconstruction, a recent innovation in CT technology, must be taken into account. The establishment of DRLs does not ensure long-term dosage optimization. Because DRLs dosages are dynamic numbers that vary with advances in technology, they must be examined on a regular basis (NCRP, report 172).[3]

In the early 1970s, the invention of CT transformed medical radiology. Physicians were able to get high-resolution tomographic (cross-sectional) pictures of inside body structures for the 1st time. Over the next 10 years, 18 manufacturers battled for a piece of the rapidly growing global CT market. The level of technical complexity rose dramatically, and CT is still evolving today, with new capabilities being investigated and created (Cunningham, 2000). The potential danger to sensitive organs is thought to be considerable because of the high doses involved in CT exams compared to the majority of diagnostic radiological procedures. As a result, knowing how to calculate the dosage from potentially high-dose exams before they are performed is beneficial. To aid in the regular computation of dosages during CT examinations, a computer model was created. This model might potentially be used to give data for regular patient dosage estimation and to compare alternative procedures before the examination (Garba, 2014).[4]

- The DRL concept was adopted by the International Commission on Radiological Protection (ICRP) in ICRP publications 60 and 73, as well as the European Directive 97/43 Euratom, as a tool to identify situations where patient doses are unusually high and urgently need to be reduced

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(ICRP, 1991; Drouet, 2007).[5] A DRLs goal is to assist prevent giving the patient radiation that isn't needed for the clinical purpose of a medical X-ray imaging task

- DRLs for diagnostic radiography should be based on doses measured in a variety of settings, including hospitals, clinics, and private practices, rather than only well-equipped institutions
- DRLs can be assessed using entrance surface doses, measured with TLD fixed on the patient's body, or the DAP, as previously mentioned because patients and the information required differ widely
- The dose length product (DLP) and the weighted (CTDIv) are ideal numbers to use as DRLs in CT. DRLs are especially beneficial for more common tests or examinations that may entail large doses or are conducted often
- It's vital to remember that the degree of picture quality can be determined by the user or automatically established by an X-ray system when setting DRLs for procedures done with digital systems.
- Per bodily examination, a minimum of 20 patients might be considered (Idris, 2014).

Methodology

This evaluation included articles based on prospective and retrospective investigations conducted by a number of scholars and researchers in northern India. The DRL for adult chest and abdomen for patients receiving CT scan in northern India was determined using a prospective and retrospective quantitative technique and a cross-sectional research design. The researchers in northern India utilized a quantitative design spreadsheet to capture the individual data. The study used numerical data and was carried out retrospectively in order to obtain more trustworthy and valid data. Data might be gathered from researchers in the region or sub region, and compared to data from other international nations, according to the principles laid out in the literature.

Data Analysis

CT Dose Index Volume (CTDIvol) and DLP are two of the data (exposure parameters) gathered from many study publications (DLP). To give solutions to the review's research concerns, the data were examined using the specified SPSS program. Descriptive and inferential analyses are the two statistical approaches used to analyze this data. The data for this review were summarized using descriptive analysis. It was used to describe the data by finding the location measure (mean) and expressing the variability of the data (standard deviation). To determine the significance, inferential statistical analysis was used (whether any difference between the researchers is due to chance or a real effect of their results). The standard DRL in the region was estimated using a 75% quartile representation.

The data were analyzed using SPSS statistical software. At 25% and 75% confidence intervals, the mean, standard deviation, and third quartile values were utilized. A comparison was done between the researcher's dosage values and data from European nations where DRLs have been established (DRLs).

Overview Discussion and Summary of the Findings

Tables 1 and 2 summarize the findings of several study publications published by various experts in the northern region of India for the chest and abdomen, respectively.

Discussion

The established DRLs for chest (CT) are seen in Table 1. CT scan in CTDI and DLP in previous literature conducted in northern India, showing that Joseph *et al*. Marry-Ann *et al*. (2017)[6] seemed to have the highest CTDI value of 18mGy, followed by (2017). (2018) and Ernest *et al*. (2018),[7] who each have a CTDI of 17mGy. With a CTDI of 9.9mGy, Abdullah (2019)[8] have the lowest CTDI, whereas Kabir *et al*. (2015)[9] has a CTDI of 10mGy. With 735mGy.cm DLP, Marry-Ann *et al*. (2018)[10] and In the established diagnostic reference values for chest (CT) scan, Ernest *et al*. (2018)[7] have the maximum DLP, whereas Kabir *et al*. (2016) have the lowest with 407mGy.cm DLP.

In several literature studies in northern India, Table 2 shows the established diagnostic reference for abdominal CT scan. Marry-Ann *et al*. (2018)[10] has the highest CTDI of 20mGy, followed by Joseph *et al*. (2017) with 19mGy, and Abba and Ibrahim (2018)[11] with 12mGy and Rilwan *et al*. (2020) with 12.7mGy. Abba and Ibrahim (2018)[11] have the greatest DLP at 2225mGy.cm, while Marry-Ann *et al*. (2018) have the lowest DLP at 1486mGy.cm; Rilwan *et al*. (2020) have the lowest DLP at 560mGy.cm.

The estimated DRLs for CT chest and abdominal exams are shown in Tables 3 and 4. The DRL should be set at the third quartile in the dosage distribution of the measured CTDIvol per series and DLP per examination, according to this review. The third quartile value was chosen as a suitable inquiry threshold because if 75% of CT units can work adequately below this dosage level, the remaining 25% should be made aware of their far less than ideal performance. To put their dosages in line with the 75 percent majority, operators of the units should be urged to change their radiography procedures by reducing the kV and mA or raising the slice thickness.

Tables 5 and 6 present the estimated DRL for chest and abdomen CT examinations which show CTDIvol of 17.25mGy and DLP of 735mGy.cm for chest and CTDIvol of 19.25mGy and DLP of 1670.75mGy.cm for the abdomen.[12,13]

Table 7 shows the evaluated DRLs for CT chest examination in relation to suggested international values; the reviewed DRLs are higher than all international values, including the DLP for the ICRP 2007 edition. This indicates that the scan parameters employed in northern India should be altered, and researchers should work diligently to develop an idea that can be utilized to reduce the radiography procedure.[14]

Table 1: Established DRLs for chest by the literature review

S. No.	Centre number used	Number of patients used	Methodology	CTDI	DLP	Location	Reference
1	4	226	Prospective Study	10	407	NC	Kabir, 2015
2	2	180	Prospective Study	18	659	NE	Joseph *et al*., 2017
3	3	131	Retrospective Study	9.9	663	NW	Abdullah 2019
4	2	171	Retrospective Study	17	735	NC	Marry-Ann *et al*., 2018
5	40	NA	Retrospective Study	17	735	NORTH	Ernest *et al*., 2018
6	4	226	Retrospective Study	12	407	NC	Kabir *et al*., 2016

CTDI: Computed tomography dose index, DLP: Dose length product, DRL: Diagnostic reference level

Table 2: Established DRLs for abdomen by the literature review

S. No.	Centre number used	Number of patients used	Methodology	CTDI	DLP	Location	Reference
1	4	226	Prospective Study	15	757	NC	Kabir, 2015
2	2	180	Prospective Study	19	1290	NE	Joseph *et al*., 2017
3	3	131	Retrospective Study	14	1397	NW	Abdullah 2019
4	2	171	Retrospective Student	20	1486	NC	Marry-Ann *et al*., 2018
5	1	100	Retrospective Study	12	2225	NC	Abba and Ibrahim, 2018
6	3	131	Retrospective Study	12.7	560	NC	Rilwan *et al*., 2020

CTDI: Computed tomography dose index, DLP: Dose length product, DRL: Diagnostic reference level

Table 3: Estimated Mean±SD, 25% and 75% Values of CTDI and DLP for Chest CT

Centre Number Used	Number of patients used	Mean±SD		25% Percentile		75% Percentile	
		CTDI	DLP	CTDI	DLP	CTDI	DLP
55	934	13.98±3.76	600.7±153.73	9.98	407	17.25	735

CTDI: Computed tomography dose index, DLP: Dose length product, DRL: Diagnostic reference level

Table 4: CTDI and DLP for abdomen CT: estimated Mean±SD, 25% and 75%

Centre number used	Number of patients used	Mean±SD		25% Percentile		75% Percentile	
		CTDI	DLP	CTDI	DLP	CTDI	DLP
55	934	15.5±3.32	1285.8±590.08	12.53	707.75	19.25	1670.75

CTDI: Computed tomography dose index, DLP: Dose length product, DRL: Diagnostic reference level

Table 5: DRLs estimated for a chest CT scan with a 75% percentile

Center number used	Number of patients used	DRLs	
		CTDI	DLP
55	934	17.25	735

CTDI: Computed tomography dose index, DLP: Dose length product, DRL: Diagnostic reference level

Table 6: DRLs for abdomen CT scan estimated at the 75th percentile

Center Number Used	Number of Patients Used	DRLs	
		CTDI	DLP
55	934	19.25	1670.75

CTDI: Computed tomography dose index, DLP: Dose length product, DRL: Diagnostic reference level

Table 7: Comparison of DRL with international value for CT chest

Dose Quantities	Reviewed DRLs	The United States 2015	India 2014	Greece 2015	ICRP 2007
CTDIvol	17.25	17	12	14.4	30
DLP	735	610	456	481	650

CTDI: Computed tomography dose index, DLP: Dose length product, DRL: Diagnostic reference level

Table 8: Comparison of DRLs with international value for abdomen

Dose Quantities	Reviewed DRLs	The United States 2015	India 2014	Greece 2015	ICPR 2007
CTDIvol	19.25	17	16	16.3	35
DLP	1670.75	860	482	758	780

CTDI: Computed tomography dose index, DLP: Dose length product, DRL: Diagnostic reference level

Table 8 compares reviewed DRLs to recommended international values for abdominal CT examination, revealing that the reviewed DRLs values are higher than all international values except the CTDIvol of the ICRP 2007 publication, although the reviewed DLP values are higher than any recommended value.[15,16] As a result, the dosages and DRLs reported here are indicative of CT facilities and practices across Northern India. Our findings establish a nationwide standard for CT dosages and should aid in the development of optimization measures to lessen the burden of CT exams across the area.

Conclusion

Within and between radiological facilities in northern India, the doses for chest and abdominal CT examinations vary greatly. These procedures' 75th percentile CTDIvol dose values are comparable to those reported internationally, including the ICRP 2007 recommendation. On the other hand, the CTDIvol and DLP for this review are significantly greater. High dosages and dose fluctuations appear to be influenced by technological and technical aspects. CT technology advancements, as well as protocol modification, including exposure and technical parameter selection, should assist in decreasing dosage fluctuations. Any study with dosage outliers over the 75th percentile should investigate as low as practically practicable dose protocols as soon as possible, while those with large dose fluctuations should explore standardizing procedures to narrow dose values.

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