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REVIEW ON DIAGNOSTIC REFERENCE LEVELS (DRLS) FOR ADULT PATIENTS UNDERGOING CHEST AND ABDOMEN COMPUTED TOMOGRAPHY SCAN IN NORTHERN NIGERIA

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ABSTRACT: *Computed tomography (CT) scan procedure has become a higher radiation dose that contributes to all medical x-ray procedures in the radiological department. Many researches in the world suggested that computed tomography presents a small fraction (5%) of the total procedures performed but contributes 34% of annual radiation doses in all medical x-ray procedures. Likewise, other investigations reported that computed tomography presents 17% of the total number of procedures performed worldwide but contributes 49% of the annual collective doses in all medical x-ray procedures. Therefore, the aim of this review is to provide a diagnostic reference level for adults that undergo chest and abdomen CT scan examinations in northern Nigeria, using the research for this region and comparing with international values to see if better optimization protocol is being practiced, since diagnostic reference levels are part of the ways of optimizing a dose in CT procedure. Based on this review, the results obtained for DRLs for the chest are 17.25mGy for CTDIvol and 735mGy.cm for DLP, while the results for the abdomen are 19.25mGy and 1670.75mGy.cm for CTDIvol and DLP respectively. Therefore, all the DRLs' values reviewed are higher than the international values compared except CTDIvol of ICRP 2007 publications. There is an urgent need for an upgrade in CT technology. Optimization of protocols, including exposure and technical parameter selection, should help reduce dose variations in the northern part of Nigeria.*

KEYWORDS: DRLs, CT Scan, CTDIvol and DLP

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INTRODUCTION

Diagnostic reference levels (DRLs) are reference dose levels in medical radio diagnostic practices for typical examinations of groups of standard-sized patients or a standard phantom, and broadly defined types of equipment. These levels are not expected to be exceeded for standard procedures when good and normal practice regarding diagnostic and technical performance is applied (European Commission, 1999). The rationale for setting national diagnostic reference level (NDRL), as stated in an International Atomic Energy Agency (IAEA) document termed Radiation Protection in Patients, emphasized the need for optimization i.e. to keep all CT doses as low as reasonably achievable within clinical ranges, since surveys of CT dose estimates have shown significant variations in practice for the same patient categories in age and size, that have undergone identical types of examinations. The importance of setting diagnostic reference levels (DRLs) cannot be over emphasized; however, it is relevant to know that diagnostic reference levels (DRLs) are not universal but specific to a country. Because of equipment and personnel training, diagnostic reference levels (DRLs) established for one country (with different CT practice and technology) may not be completely relevant to another country's circumstances (Ogbole & Obed, 2014 and Olowokere *et al.*, 2012). Iterative reconstruction which is an advancement in computed tomography CT technology must also be considered when setting diagnostic reference level (DRL) or comparing one practice to another. Establishing diagnostic reference levels (DRLs) alone does not guarantee long term optimization of doses. Doses must be reviewed from time to time since diagnostic reference levels (DRLs) doses are dynamic values that change overtime with changes in technology (NCRP, report 172).

The development of computed tomography (CT) in the early 1970s revolutionized medical radiology. For the first time, physicians were able to obtain high-quality tomographic (cross-sectional) images of internal structures of the body. Over the following 10 years, 18 manufacturers competed for the exploding world CT market. Technical sophistication increased drastically, and even today, CT continues to mature with new capabilities being researched and developed (Cunningham, 2000). Because of the high doses involved in CT examinations relative to the majority of diagnostic radiological examinations, the potential risk to the sensitive organs is considered to be high. Hence, it is useful to be able to calculate the dose from potentially high dose examinations before they are carried out. A computer model was developed to assist in routine calculation of doses during CT examinations. This model could also be used to provide information for routine patient dose estimation, as well as allow different protocols to be evaluated prior to the examination (Garba, 2014).

The concept of the diagnostic reference level (DRL), as a tool to identify situations where patient doses are unusually high and in most urgent need of reduction, was therefore adopted by the International Commission on Radiological Protection in ICRP publications 60 and 73, and by the European Directive 97/43 Euratom (ICRP, 1991; Drouet, 2007). The objective of a diagnostic reference level is to help avoid radiation dose to the patient that does not contribute to the clinical purpose of a medical x-ray imaging task. This is accomplished by comparison between the numerical value of the diagnostic reference level derived from relevant regional, national, or local data and the mean or other appropriate value observed in practice, for a suitable reference group of patients or a suitable reference phantom (ICPR, 2001). The guidelines for establishing DRLs as mentioned by European Commission are as follows (Idris, 2014):

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- DRLs for diagnostic radiology should be based on doses measured in various types of hospitals, clinics and practices, and not only in well-equipped hospitals.
- As mentioned before, because patients and the information required differ widely, DRLs are only applicable to standard procedures, standard phantoms or groups of standard-sized patients, and for specific groups of children distinguished by age, size and weight.
- DRLs can be assessed using entrance surface doses, measured with TLD fixed on the patient's body, or the DAP (Gycm2).
- For CT, the weighted CT dose index ($CTDI_v$) and the dose length product (DLP) are suitable quantities to be used as DRLs.
- DRLs are particularly useful for more common examinations or examinations which may involve high doses or are frequently performed.
- When setting DRLs for procedures performed with digital systems, it is important to remember that the level of image quality can be selected by the user or automatically set by an X-ray system.
- A minimum of twenty (20) patients could be considered per body examination (Idris, 2014).

METHODOLOGY

This review encompassed the research papers based on prospective and retrospective studies done by many scholars and researchers in northern Nigeria. This study adopted a prospective and retrospective quantitative methodology and cross-sectional research design to determine the diagnostic reference level for adult chest and abdomen, for patients undergoing computed tomography CT scan in northern Nigeria. A quantitative design spreadsheet was used to record the individual data by the researchers in northern Nigeria. The study involved the use of numerical data and was conducted retrospectively to ensure more reliable and valid data. Based on the guidelines stipulated in the literature, the data could be obtained either from researchers in the region or subregion and compared with the other international countries.

Data Analysis

The data (exposure parameters) obtained from different research articles include: Computed Tomography Dose Index Volume (CTDIvol) and Dose Length Product (DLP). The data were analyzed using recommended SPSS software to provide answers to the research problems of this review. The two statistical methods employed for the analysis of this data are descriptive and inferential analysis. The descriptive analysis was used to summarize the data for this review. It was used to give a description of the data by determining the measure of location (mean) and expressing its variability (standard deviation). Inferential statistical analysis was employed to measure the significance (whether any difference between the researchers is due to chance or a real effect of their results). It was represented using 75% quartile and this was used to estimate the standard diagnostic reference level (DRL) in the region.

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Data was analyzed using SPSS statistical software. The mean, standard deviation and third quartile values at 25% and 75% confidence intervals were used. Comparison was made between the researcher's dose values and reported data from the European countries where there are established diagnostic reference levels (DRLs).

Overview Summary of the result and Discussion

The results of various research articles by different scholars in the northern part of Nigeria were summarized in tables 1 and 2 for chest and abdomen respectively.

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	Abdullahi *et al.*, 2019
4	2	171	Retrospective Study	17	735	NC	Mary-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

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	Abdullahi *et al.*, 2019
4	2	171	Retrospective Student	20	1486	NC	Mary-ann *et al.*, 2018
5	1	100	Retrospective Study	12	2225	NC	Abbam & Ibrahim, 2018
6	3	131	Retrospective Study	12.7	560	NC	Rilwan *et al.*, 2020

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DISCUSSION

Table 1 shows the established diagnostic reference levels (DRLs) for chest (CT) i.e. computed tomography scan in CTDI and DLP in the previous literature conducted in northern Nigeria, which presents that Joseph *et al.* (2017) have the highest CTDI value of 18mGy, followed by Mary-ann *et al.* (2018) and Ernest *et al*. (2018) each with CTDI of 17mGy. Abdullahi *et al.* (2019) have the lowest CTDI of 9.9mGy with Kabir (2015) of 10mGy. Mary-ann *et al.* (2018) and Ernest *et al*. (2018) also score the highest dose length product (DLP) in the established diagnostic reference levels for chest (CT) scan, each with 735mGy.cm, while Kabir *et al.* (2016) record the lowest with 407mGy.cm DLP.

Table 2 presents the established diagnostic reference for abdominal computed tomography scan in different literature reviews in northern Nigeria. Mary-ann (2018) scores the highest CTDI of 20mGy with Joseph *et al.* (2017) of 19mGy, while Abbam & Ibrahim (2018) record the lowest CTDI value of 12mGy and Rilwan *et al.* (2020), 12.7mGy. The highest DLP is recorded by Abbam & Ibrahim (2018) with value 2225mGy.cm and Mary-ann *et al.* (2018), 1486mGy.cm; the lowest DLP is recorded by Rilwan *et al*. (2020) which is 560mGy.cm.

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

Table 4: Estimated Mean±SD, 25% and 75% Values of CTDI and DLP for Abdomen CT

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

Table 3 and table 4 present the estimated diagnostic reference levels for CT chest and abdomen examinations. In this review, it is recommended that the DRL should be set at the level of the third quartile in the dose distribution of the measured CTDIvol per series and DLP per examination. The third quartile value is chosen as an appropriate investigation level on the grounds that if 75% of the CT units can operate satisfactorily below this dose level, then the remaining 25% should be made aware of their considerably less than optimal performance. Operators of the units should be encouraged to adjust their radiographic protocols by lowering the kV and mA or increasing the slice thickness to bring their doses in line with the 75% majority.

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Table 5: Estimated DRLs for Chest CT scan with 75% Percentile

Centre Number Used	Number of Patients Used	DRLs	
		CTDI	DLP
55	934	17.25	735

Table 6: Estimated DRLs for Abdomen CT Scan with 75% Percentile

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

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 abdomen.

Table 7: Comparison of the Review DRL with International Value for CT chest

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

Table 7 presents the comparison of the reviewed DRLs for CT chest examination with recommended international values; the reviewed DRLs are greater than all the international values, including the DLP for ICRP 2007 publication. This shows that the scan parameters used in northern Nigeria need to be adjusted, and the researchers need to work tirelessly in bringing the idea that will be used in reducing the radiographic protocol.

Table 8: Comparison of the Review DRLs with International Value for Abdomen

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

Table 8 presents the comparison of reviewed DRLs with recommended international values for abdominal CT examination, which shows that the reviewed DRLs values are above all international values excluding the CTDIvol of ICRP 2007 publication, but the reviewed DLP values are greater than any recommended value. Therefore, the reported doses and DRLs values are representatives of CT facilities and practices in northern Nigeria. Our findings provide a national benchmark for CT doses and should facilitate optimization strategies to reduce the dose burden from CT examinations across the region.

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CONCLUSION

There are very wide variations in doses for chest and abdominal CT examinations within and between radiological facilities in northern Nigeria. The 75th percentile CTDIvol dose values for these procedures are comparable to those reported international values, including the recommended ICRP 2007. However, the CTDIvol and DLP for this review are considerably higher. Technological and technical factors appear to be significant contributors to high doses and dose variations. Upgrade in CT technology, optimization of protocols including exposure and technical parameter selection should help reduce dose variations. Any examination with dose outliers above the 75th percentile urgently needs to explore as low as reasonably practicable dose protocols, whilst those with wide dose variations should consider standardizing protocols to narrow dose values.

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