

Determination of Computed Tomography Diagnostic Reference Levels in North-Central Nigeria

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Aims and objectives

The aim of this study is to estimate computed Tomography (CT) dose levels for the most common CT examinations in North-Central Nigeria. CT machine generated dose descriptors; volume weighted CT dose index (CTDI_{vol}) in mGy and dose length product (DLP) in mGycm delivered to patients undergoing head, chest and abdominal CT examinations were considered for the establishment of a Regional dose reference levels (RDRL). This estimate is then used through inter-comparison studies as a means by which practice in this region is compared to recommended standard CT practices. The outcome is expected to ascertain whether better optimization of patient exposure in CT is being practiced in this study population or not.

Methods and materials

This study is a retrospective study of prospectively acquired data. And permission was granted by the research and ethical committee of the various hospitals. This study adopts the European Commission (EC) [1], American College of Radiology (ACR, resolution-47, 2013) [2] in collaboration with American Association of Physicist in Medicine (AAPM) [3], International Atomic Energy Agency (BSS) [4], and the International Commission on Radiological Protection (ICRP)[5]; recommended guidelines to determine DRLs in radio-diagnostics. This guideline states that; weighted CT dose index (CTDI_w) now replaced by volume weighted CT dose index (CTDI_{vol}) and dose length product (DLP) are the appropriate dose quantities for the establishment of DRLs for optimizing patient exposure in CT.

Four multi-slice CT scanners that display dose parameters (CTDI_{vol} and DLP) were selected randomly from in north-central region of Nigeria. These include 4, 6, 16 and 64-slices CT scanners. Selection of examination type surveyed was based on existing literature from survey of the most commonly performed CT scan in the country [6, 10]. Individual patient's CT machine generated dose data (CTDI_{vol} in mGy and DLP in mGycm) and scan parameter data (kV, mA, scan time, pitch, and slice thickness) were recorded for at least ten patients in each type of examinations from each center. Patient weight was taken using a mobile weighing scale in order to ensure that only standard size adult patients (70±10kg) were surveyed [7].

The local center DRLs for each center was estimated based on the rounded 75th percentiles from the mean of the dose values (CTDI_{vol} and DLP) and for the region by compiling results from all the centers surveyed [8]. Statistical analysis was performed using Microsoft Excel 2010 version. The analysis of results employed the use of descriptive and inferential methods of data analysis. Quantitative variables were

expressed by descriptive analysis to summarize and show variability of the data from the study in mean, range and standard deviation.

A CT dosimetry software ImPACT CT patient dosimetry calculator [9], version 1.0.4, (ImPACT, London, England) was used to validate and compare the dose values generated by the various CT scanners surveyed in order to ascertain the reliability of machine generated dose values. The ImPACT scan dose evaluator with National Radiological Protection Board SR250 Monte Carlo data set is a system that models the conditions of exposure on a mathematical phantom for a range of common makes of CT scanners [11]. The software package provides values of CT dose index; these include CT dose index in air, weighted CT dose index, CTDIvol, and the corresponding value of DLP when scanner specific information and scan parameter information are entered. The software also calculate effective dose using the National Radiation Protection Board (NRPB) organ dose coefficients with International Commission on Radiological Protection (ICRP) 103 organ weighing factors.

Results

A total of 226 patient's data was collected, out of which 69.1% were male and 30.9% were female, they had a mean weight of 69.8 kg. Eighty-eight brain scans (38.9% of data), 60 chest scans (26.5% of data) and 78 abdominal scans (34.5% of data) were surveyed from the 4 participating centers (one private and three public hospitals).

Patient's age ranged from 16-90 years, since hospital age classification in Nigeria considered sixteen years of age as an adult [14]. This study presents estimated dose values for sequential scan mode for its brain CT scan. Summary of statistical distribution of the study data is presented in Table 1.

Dose estimates in CTDIvol and DLP for CT centers under study are presented in Figure 1 and Figure 2, respectively. The centers are denoted by alphabets A, B, C, and D. As shown center B presents with the highest dose values in terms of CTDIvol while center C reports the lowest dose values in terms of DLP. Scan parameters; kV, mA, pitch factor, scan time, scan length and slice thickness have been observed to influence dose. The kV, mA and scan time have direct proportional relationship with absorbed dose. All the centers adopt different parameters (kV, mA, and scan time) for the same type examination and hence the varying dose report.

Comparison of estimated DRLs in terms of dose quantities; CTDIvol and DLP from this study to that from United Kingdom [11] and European Commission [1] is presented in Table 3. The UK study surveyed only multi-slice CT scanners and the European Commission (EC) study surveyed mainly single slice CT scanners. As shown, diagnostic

reference levels in North-Central Nigeria is less than EC 1999 DRLs but higher than the more recent UK diagnostic reference levels for head and abdominal CT scan.

The effective dose estimates were calculated using the adult normalized values of effective dose per dose-length product (DLP) over various body regions as presented in Figure 3.

Table 4 also presents the mean effective doses from this study compared to average and range of effective dose values for CT examinations compiled from reported literatures. They fall within ranges reported in literature however, above the average effective doses for chest and abdomen and below average (1.7 mSv) for head scan.

Figure 4 shows a comparison of scan length (a factor that influence DLP), head and abdominal CT scan in this survey use longer scan length than in the two comparing references [UK (2003) and NRPB (2005)] except for chests CT scans. This study however, estimated that scan length can still be reduced by 12.3%, 14.4% and 11.5% for head, chest and abdomen, respectively without losing any area of diagnostic benefit.

Images for this section:

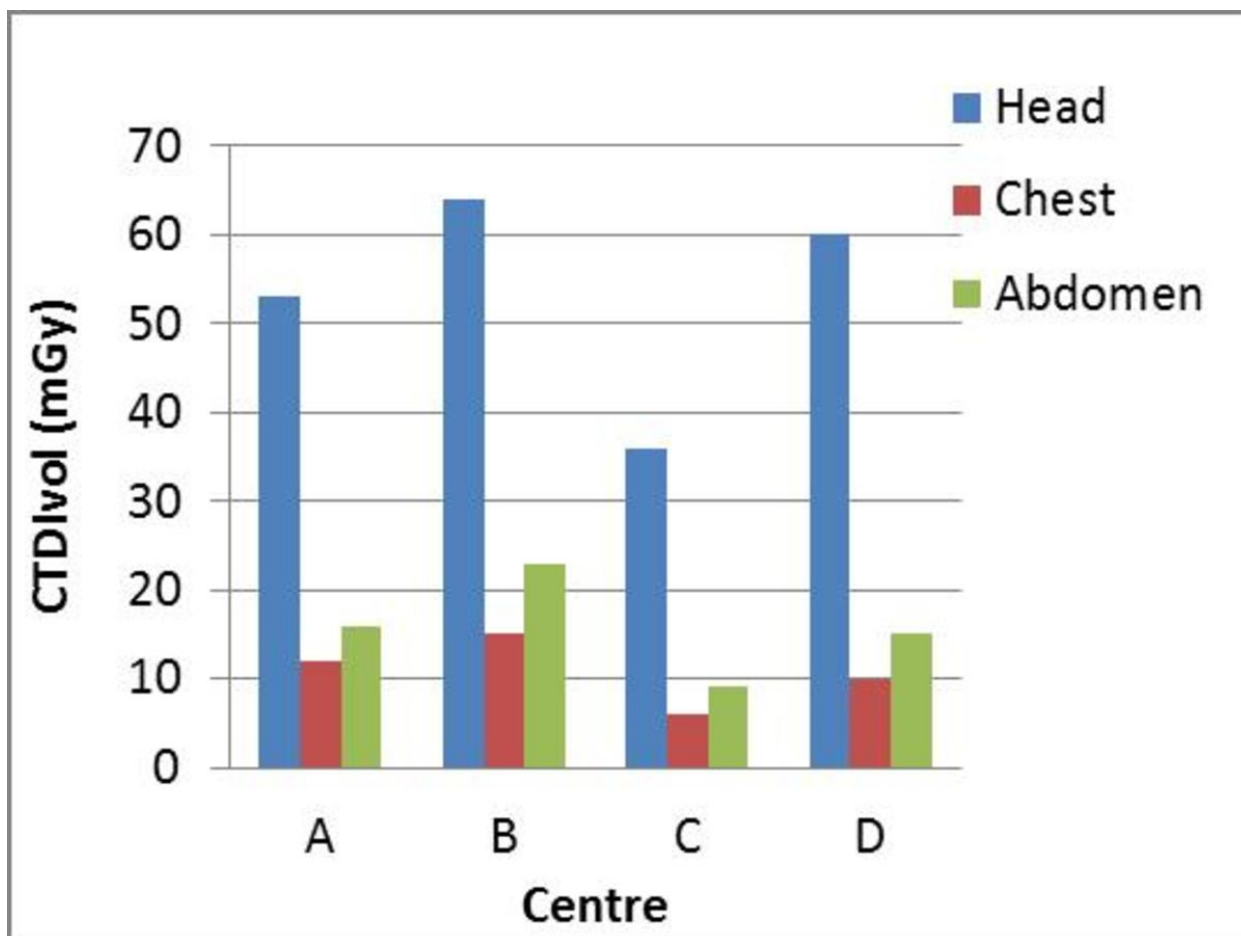


Fig. 1: CTDIvol (DRLs) for CT Centers Surveyed

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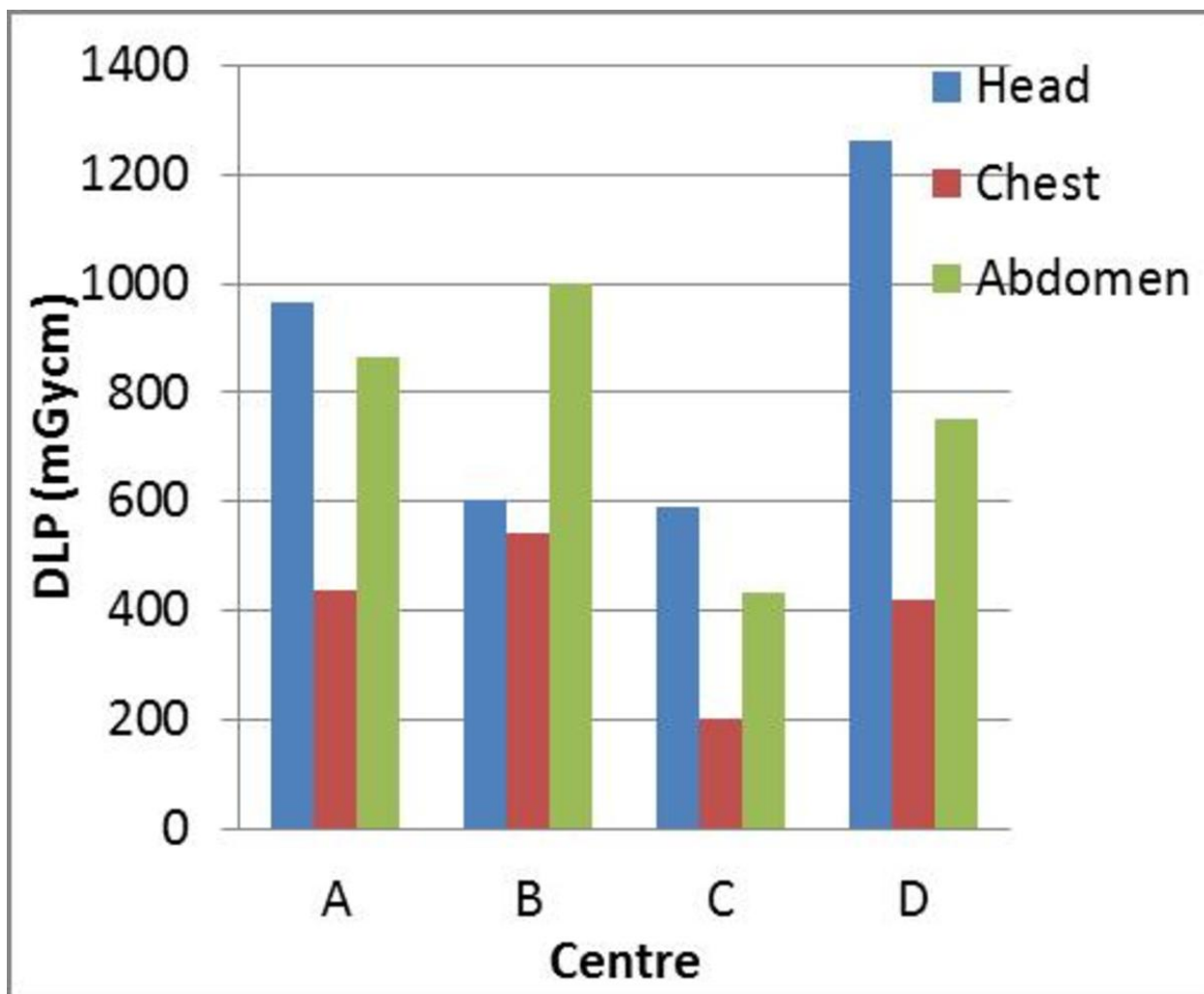


Fig. 2: DLP for CT Centers Surveyed

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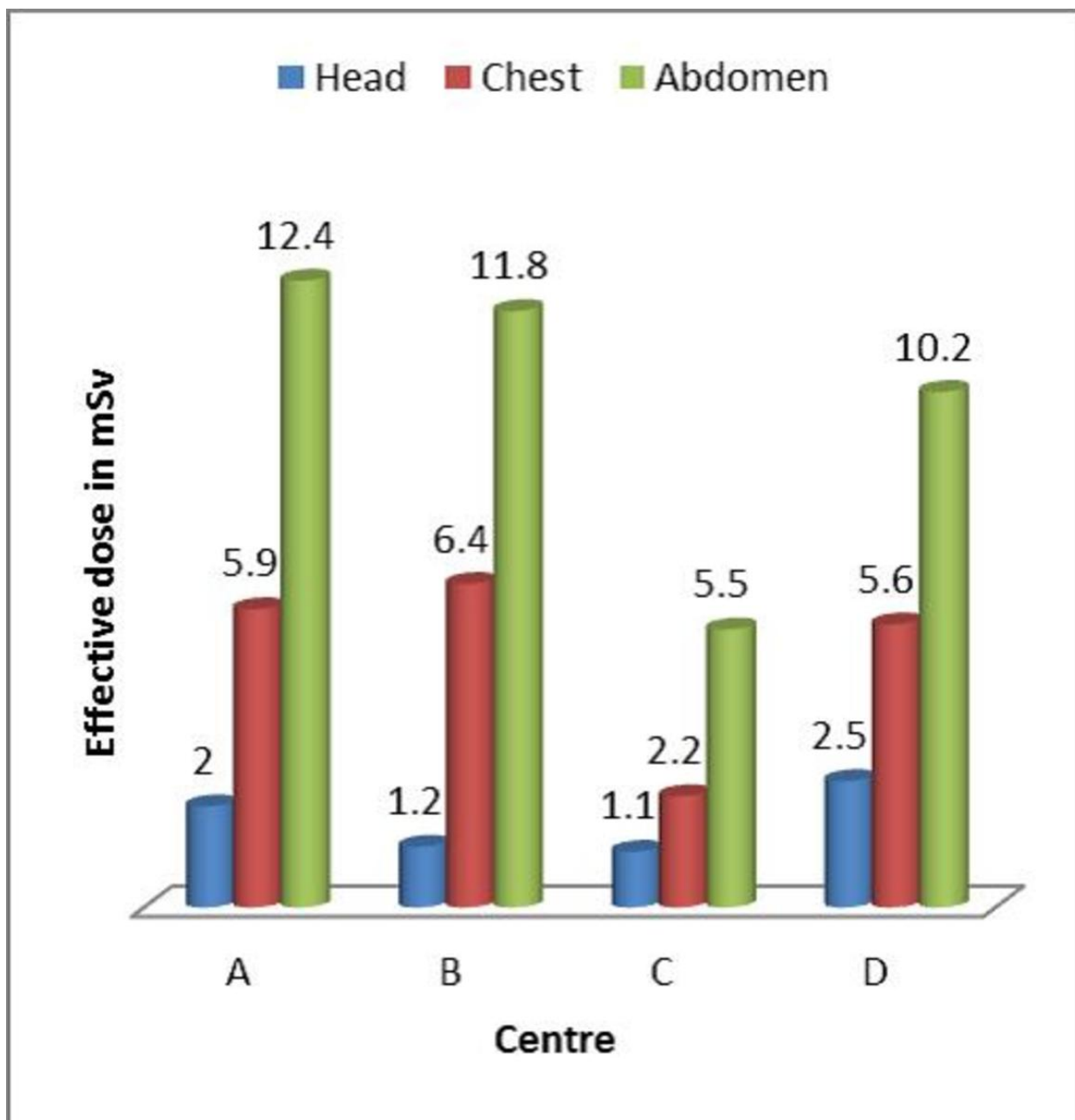


Fig. 3: Estimated Mean Effective Dose across Centers for Head, Chest, and Abdominal CT Scan

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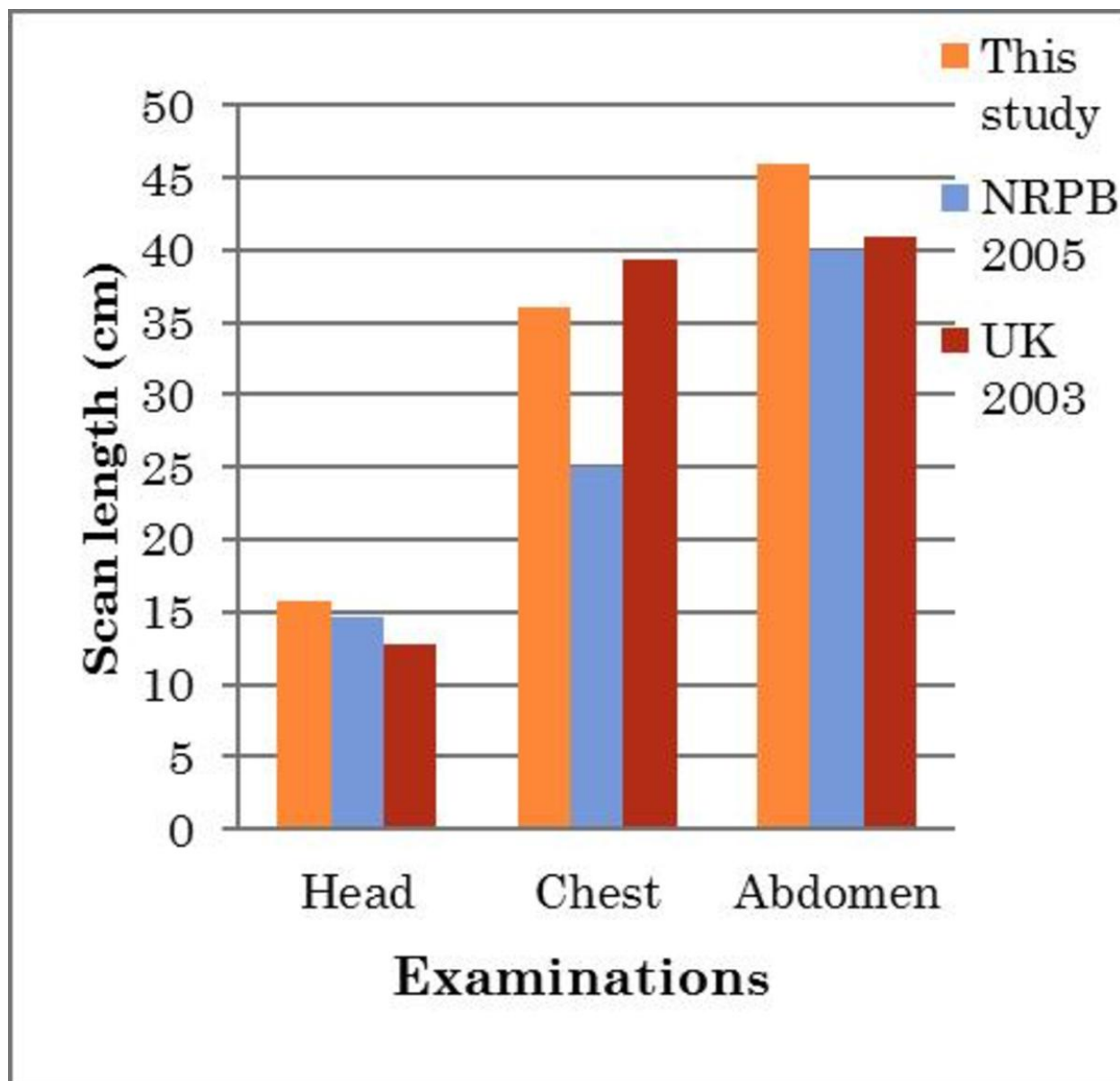


Fig. 4: Comparison of Scan Length

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Examination	Number of participants(N)	Dose Parameter	Mean	Range	75 th Percentile
Head	88	CTDI _{vol}	52.2(±10)	25-69	60
		DLP	841.5(±324)	320- 1968	1024
Chest	60	CTDI _{vol}	8.8(±4)	2-23	10
		DLP	333(±173)	72-1048	407
Abdomen	78	CTDI _{vol}	12(±5)	4-23	15
		DLP	590(±260)	218-1149	757

Table 1: Statistical Distribution of Study Data

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Diagnostic Reference Levels	Examinations		
	Head	Chest	Abdomen
CTDI _{vol} (mGy)	60	10	15
DLP (mGy.cm)	1024	407	757

Table 2: Estimated regional diagnostic reference levels

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Examination	Mean value	75th percentile value	European DRL	U.K Study2003
Head				
CTDI _{vol} (mGy)	52	60	60	65
DLP(mGy.cm)	841	1024	1050	930
Chest				
CTDI _{vol} (mGy)	8.8	10	30	14
DLP(mGy.cm)	333	407	650	580
Abdomen				
CTDI _{vol} (mGy)	12	15	35	14
DLP(mGy.cm)	590	757	780	560

Table 3: Comparison of diagnostic reference levels (DRLs)

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Examination	Average Effective Dose (mSv)	Values reported in literatures (mSv)	Mean effective Dose from this study (mSv)
Head	2	0.9-4.0	1.7
Chest	7	4.0-18.0	5.0
Abdomen	8	3.5-25	11.9

Table 4: Mean effective doses from this study compared to average and range of effective dose values for computed Tomography examinations compiled from reported literature[15]

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Conclusion

This study represents the collection of estimated local computed tomography DRLs in North-Central region of Nigeria and a means by which practice in the region can be compared to others. It revealed enormous variations between the different centers in reported local DRLs and individual patient doses. The reasons for these variations in line with many DRL studies [12, 13, 14] are mainly attributed to different exposure parameters and radiographic techniques. This shows a huge optimization potential among almost all the centers and standardization of practice is also lacking.

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