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Original Article

Establishment of Diagnostic Reference Levels for Adult Head CT Examinations in Rivers State, South-South Nigeria

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Abstract

The work aimed at establishing DRLs for adult CT examination of the head in Rivers State, Nigeria. The dose report and scan parameters for adult Head examination was retrospectively surveyed during the study period of four months in three CT center. Sixty-nine patient folders, comprising twenty-five subjects for center A, twenty-three subjects for center B, and twenty-one subjects for center C were included. Data on CT dose index (CTDIvol) and dose length product (DLP) displayed on CT scanner console from three (3) selected hospitals were recorded for each facility. The percentile (75th) was assessed for all centers to set up center-unique DRLs. Lastly, a summed percentile (75th) for mean of DLP and CTDIv in the entire centers was assessed to obtain DRLs in adult Head examinations across investigated area. Facts were analyzed with the aid of SPSS (version 25.0). The modern files (digital) of 24 female and 45 male patients with age bracket 16-100 years old were analyzed. Centre-unique percentile (75th) of mean DLP and CTDIv of three centers A, B, and C were 39 mGy and 820 mGy.cm, 70.9 mGy, and 1330 mGy.cm, 55 mGy, and 1158 mGy.cm, respectively. The head CT examination DRLs for the area was 54.9 mGy and 1103 mGy.cm. The Head CT examination's DRLs for the state of Rivers has been obtained. Nonetheless, variation between CT scan center was noted, CTDIvol is lower than recommendations of European Commission (EC) of 60mGy. The DLP is slightly supper than EC value of 1000 mGy.cm. Personnel training and more awareness on optimization of dosage may still aid to further guide down the dosage of radiation within the location compared to international values. Therefore, centers with fairly lower values than the state derived DRLs (LDRL) should retain their values, while those whose values are higher should implement dose optimization.

Keywords: Dose Optimization, Computed Tomography, Diagnostic Reference Levels, Volume Computed Tomography Dose Index, Dose Length Product.

Introduction

CT (Computed Tomography) is a vital technique in Medical imaging for the diagnosis of various ranges of medical cases. Because of the evolution of sophisticated machines (CT), newly discovered professional equipment has continued to appear in the world of diagnostic medicine. Initially, the numeral machines (CT) and consequently the diagnostic investigations have outstandingly been on the increase worldwide [1]. Notwithstanding, CT is connected with proportionately supper dosage of radiation, with a correlated growing risk of tumorigenesis [2-4]. Consequently, applying the theory of the international commission of radiological protection (ICRP) in protection, justification, optimization as well as minimization of radiation is highly vital to quench exposure unnecessary to ionizing radiation. At the center of optimization is the start of DRLs (diagnostic reference levels), which was first proposed by the ICRP in 1996 [5]. The DRLs are not dose limits but is a means to evaluate the practice. The International Commission on Radiological Protection (ICRP) recommending diagnostics reference levels (DRLs) be used by regional, national, and local authorities so as to reduce the patient dose during radiological examinations to as low as reasonably achievable (ALARA) [6-8]. There had not been CT DRLs in Rivers State, hence this study aimed to establish a local DRLs towards contemplating a proposal of regional DRLs in Rivers State for the adult head CT examinations using two primary dosimetrics; Volumetric Computed Tomography Dose Index (CTDIv), and Dose-Length Product (DLP).

Materials and Methods

Ethical Consideration

Ethical permission and informed consent were granted by the Ethical Committee of the Studied Centre in line with Helsinki declaration on research involving human population. Also, patient confidentiality was maintained.

Study Design and Period

The study was performed using three CT scanners, namely two (2) GE and one (1) SIEMENS for a period of eight (8) months.

Dose Data Collection

The dose report and scan parameters for adult Head examination was retrospectively surveyed during the study period of four months in three CT center. The patient considered population of modern (digital) CT was those of examined subjects in 2022 whom ages were ≥ 16 years old. Sixty-nine patient files, composing twenty-five subjects for center A, twenty-three subjects for center B and twenty-one subjects for center C were included. Data on CT dose index (CTDIvol) and dose length product (DLP) displayed on CT scanner console from three (3) selected hospitals were recorded for each facility. The percentile (75th) was assessed for all centers to set up center-unique DRLs. Lastly, a summed percentile (75th) for mean of DLP and CTDIv in the entire centers was assessed to obtain DRLs in adult Head examinations across investigated area. Facts were analyzed with the aid of SPSS (version 25.0).

Results

Modern (digital) files for 69 patients were surveyed for Head CT examinations. This includes; 20, 13 and 12 male patients for centers A, B, and C, respectively. While 5, 10, and 9 females' patients for center A, B, and C were extracted. Therefore, 65.2% (45) male patients and 34.8% (24) female patients

Table 1 Details of facilities, model, manufacturer, configuration, manufactured year and of installed year and result of patient head characteristics

Centers	Manufacturer	Model	Configuration	Manufactured Year	Installed Year	No. of Patients	Age (Years) (Mean ± SD)
A	Siemens	Somatom	16 – slice	2019	2019	25	49.20 ± 12.62
B	GE	Brivo	8 – slice	2015	2015	23	60.05 ± 17.95
C	GE	Bright speed	4 – slice	2006	2017	21	57.60 ± 14.17

Table 2 Result of exposure parameters for head CT

Centre	Kv	mAs	Scan Time (sec)	Scan Range (mm)
Centre A	120	158. ± 48.3	24.8	20.1 – 30.50
Centre B	120	195.4 ± 48	1.00	1.00 – 1.00
Centre C	120	241 ± 64.4	0.73	0.50 – 1.00

were recruited for the study. The participants' age ranges from 22-90 years. Therefore, the results were compiled in the following tables that ensued (Table 1 , 2).

The mean kVp values for head CT examination in center (A), (B), and (C) are all the same. The scan time for center A, B, and C were 24.8 sec, 1.0 sec and 0.73 sec, respectively (Table 3-5).

Table 3 Dose characteristics of the studied subjects

Centers	Body Region	CTDIv (mGy) Mean ± SD	DLP (mGy.cm) Mean ± SD	75th Percentile (Third Quartile)
Centre A	Head	37.21 ± 1.99	758.3 ± 127.2	39.0 820.0
Centre B	Head	68.0 ± 7.47	1233.8 ± 329	70.9 1330.5
Centre C	Head	53.4 ± 4.1	1054.9 ± 179	55.0 1158.7

Table 4 Combined dose characteristics and DRL of the subject (HEAD) for the state

Body Region	CTDIv (mGy) Mean ± SD	DLP (mGy.cm) Mean ± SD	75th Percentile (Third Quartile)
Head	52.9 ± 4.5	1015.6 ± 212	54.9 1103.0

Table 5 Comparison with other works

Studies	Location	Year	CTDIv (mGy)	Percentage Variation from Present Study	DLP (mGy.cm)	% Variation
Present study	South-south, Nigeria	2023	54.9		1103	
Adejoh [7]	Southeast, Nigeria	2017	66	16.8	1444	30.8
Garba [8]	Northeast Nigeria	2015	76	27.7	789	28.4
Abdulkadir [9]	Northcentral, Nigeria	2016	60	8.5	1024	
Santos [10]	Portugal	2014	75	26.8	1010	8.4
Lee [11]	Australia	2020	52	5.3	880	20.2
Treier [12]	Switzerland	2010	60	8.5	800	27.5
EC [13]	Europe	2014	60	8.5	1000	9.3
UK [14]	UK	2013	65	5.5	930	15.7

3.1. Results Analysis

Figure 1 depicts that the scan time at center A was recorded as the highest recorded, followed by center B then center C with least scan time. On the scan parameters (Figure 2), equal values of kV were recorded throughout the centers while on the other hand, center C has the highest value of mAs, followed by center B, and then center A with the lowest mAs.

Comparing the results from the current study (South-South geopolitical zone) with other works published in different parts of Nigeria, Figure 3 showed that the current work has CTDIv that is inferior to the CTDIv recorded in previous studies that were carried out in the remaining five (5) geopolitical zone across the country.

The CTDIv obeys a particular trend with Garba *et al.* [9] (North-East geopolitical zone) as the highest, and then Ogbole and Obed [10] (South-West geopolitical zone), followed by Adejoh *et al.* [11] (South-East geopolitical zone), and then Abdullahi *et al.* [12] (North-West geopolitical zone), followed by Abdulkadir *et al.* [13] (North-Central geopolitical zone) and lastly the current work (South-South geopolitical zone) which has the least CTDIv.

On the DLP, the current study (South-South geopolitical zone) was compared with other works published in different parts of Nigeria, Figure 4 depicted that the DLP obeys a particular trend with Abdullahi *et al.* [12] (North-West geopolitical zone) as the highest, then Ogbole and Obed (2014) [10] (South-West geopolitical zone), followed by Adejoh *et al.* [11] (South-East geopolitical zone), then current work, (South-South geopolitical zone), followed by followed by Abdulkadir *et al.* [13] (North-Central geopolitical zone), and then the least, which is Garba *et al.* [9] (North-East geopolitical zone).

Comparing the results from the current study (South-South geopolitical zone, Nigria) with other international works, Figure 5 showed that the current work has CTDIv that is inferior to the CTDIv recorded in Portugal as reported by Santos *et al.* [14] and European Commission [15]. Figure 6 showed that the current work has DLP that is superior to the DLP recorded in Portugal as reported by Santos *et al.* [14] and European Commission [15].

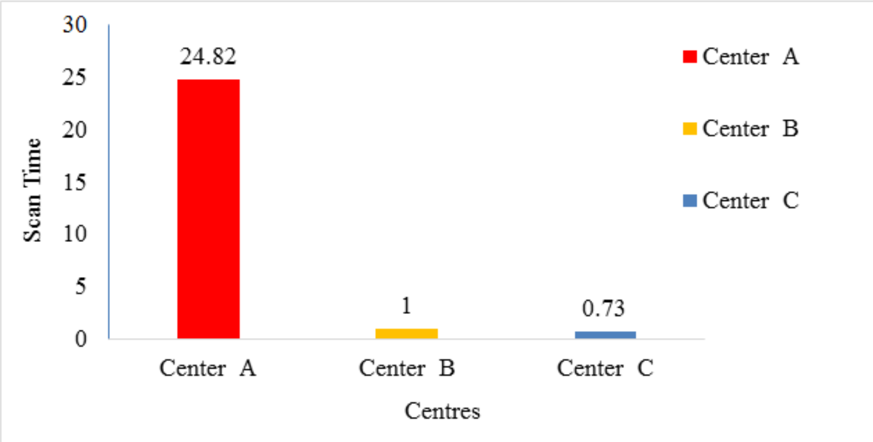

Figure 1 Variation of scan time among the study centers

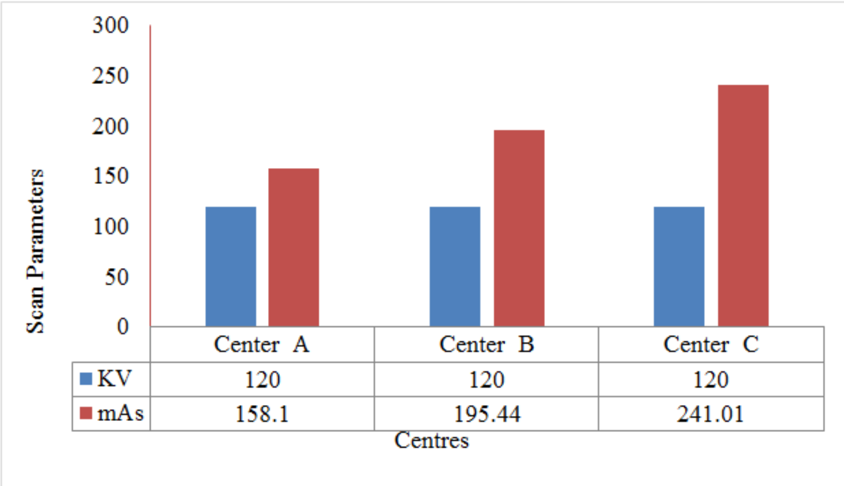

Figure 2 Variation of scan parameters among the study centers

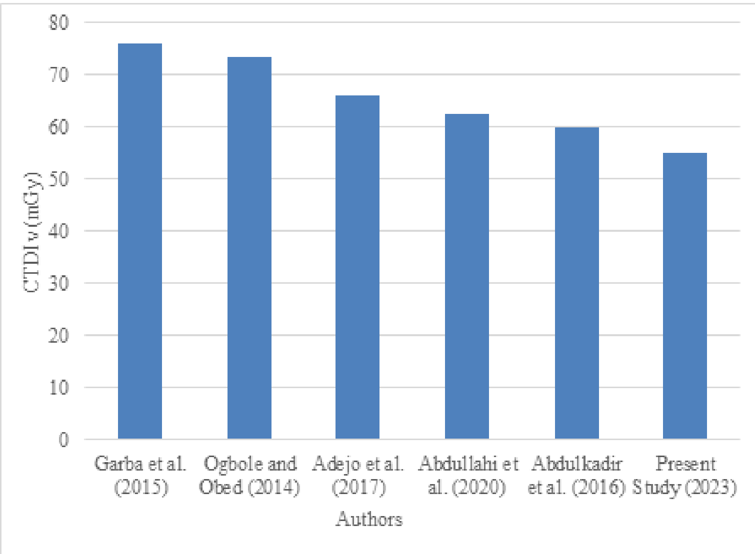

Figure 3 Comparison of DRL from the current study with other published works in Nigerian in terms of CTDIv (mGy)

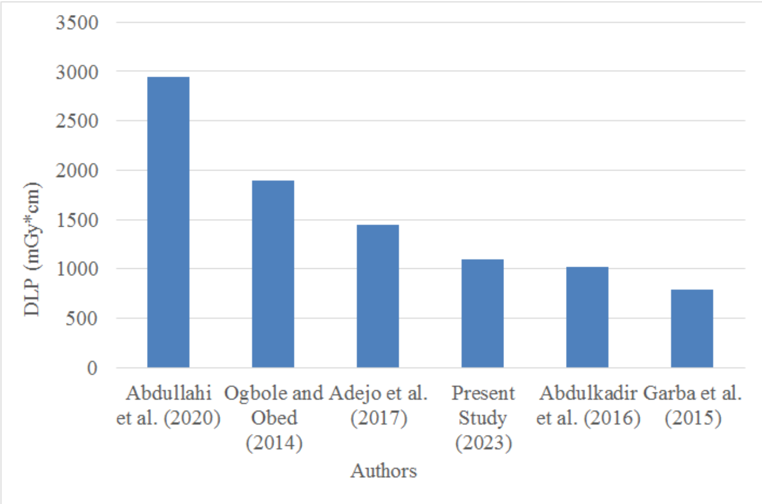

Figure 4 Comparison of DRL from the current study with other published works in Nigerian in terms of DLP (mGy.cm)

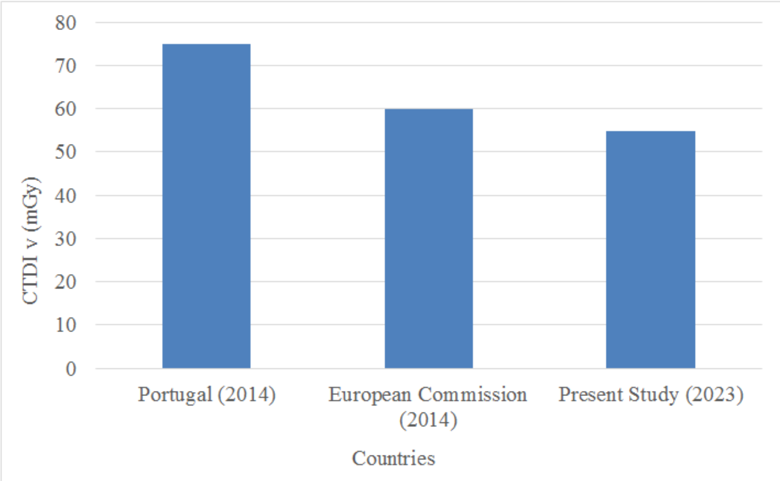

Figure 5 Comparison of DRL from the current study with other international works in terms of CTDIv (mGy)

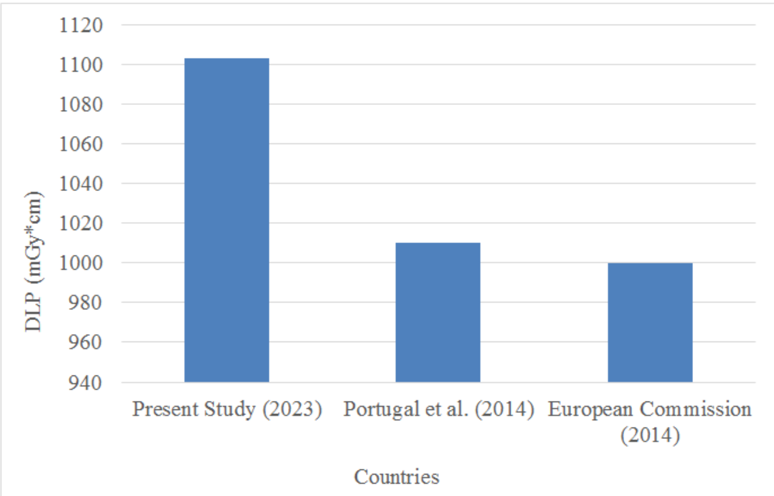

Figure 6 Comparison of DRL from the current study with other international works in terms of DLP (mGy.cm)

Discussion

The utilization of DRL in most victims' examinations can be friendly in radiogenic evaluation of risk [15]. Investigation of this work yielded a vital variable center-unique CTDIv and DLP respective values of (39.0 - 70.9) mGy and (820 - 1330.5) mGy.cm. These variations are mostly the reason for the setup of a consensus DRL [16]. The summed CTDIv and DLP were respectively 54.9 mGy and 1103.0 mGy.cm. CTDIv in this work is lower than the study from European Union (60 mGy), Switzerland (60 mGy), UK (65 mGy), and Portugal (75 mGy), but slightly higher to works from Australia (52 mGy) by Lee *et a.*, (2014), as presented in Table 5, and Addis Abba (53mGy) by Kumasi *et al.* (2014) [17] Our DLP is slightly higher than works from UK (930 mGy.cm) and Australia (80 mGy.cm), it was still lower than the results in Addis Abba (1210 mGy.cm). Multi-center survey in Nigeria show moderate variations of (5.3% - 26.8%) in CTDIv and Switzerland (8.4% - 27.5%) in DLP, but slightly higher than the works from European Commission (1000 mGy.cm) and Portugal (1010 mGy.cm). This justifies the necessity of National DRL to fill the vacancy of variability of DRLs from the same location. The CTDIv being the intensity of radiation from a CT machine is considerably determined by mAs (tube current-time) and kVp (tube voltage), these inclusively formed intensity of the radiation [18, 19] as well as the collimation and pitch [20]. Therefore, if the parameters aforementioned are maintained unchanged as mostly modulation of current in tubes that are automatic does, a comparable CTDIv stem notwithstanding the victim size or examine region of anatomy. Modulation of current for the tubes that are automatic is a method for altering the mAs, in agreement with the anatomical diameter of the subject's and for holding the CTDIv fixed in despite that, the three centers studied operated in that mode. The CT radiographer's skill and their awareness of CT patient dose of radiation are important in arranging the optimal intensity of radiation while ensuring reduced radiation dose and production of highly diagnostic image quality with minimal noise generation. (while centre A, B, and C had 39 mGy, 70 mGy, and 55 mGy CTDIv respectively, their respective values for DLP were 820 mGy.cm, 1330 mGy.cm, and 1158 mGy.cm for centres A, B, and C). Our study shows Centre A, B, and C had 39 mGy and 820 mGy.cm, 70mGy, and 1330mGy.cm, and 55mGy and 1158mGy. cm as CTDIv and DLP, respectively. Therefore, center A had CTDIv and DLP values lower than the derived CTDIv and DLP of 54.9 mGy and 1103.0 mGy.cm. This could be due to adjustment of scan range, mA and kVp. centre C had CTDIv and DLP values comparable to the derived CTDIv of 54.9 mGy, and 1103 mGy.cm, while centers D had CTDIv and DLP values higher than the derived CTDIv and DLP of 54.9 mGy and 1103 mGy.cm. The summation of intensity of radiation and scan range is termed as the DLP [21, 22] notwithstanding the CTDIv value or capacity of the slice for the scanner, least values of DLP is resulted from the smaller values of the scan range. CT examination dose survey therefore doesn't support any center exclusion that have satisfied inclusion criteria [23, 24]. It is therefore important to note that the scope of the covered length of the body during scanning doesn't alter the CTDIv values but surely, DLP is tempered. The length of scanning in a given kind of CT exams can change because of the victim's pathology, victim's size and possibly, the operating personnel's experience. Due to these facts, protocols of CT require regular review in order to minimize irradiation to the collimated anatomical region being investigated only [25]. The optimization justification for the CTDIv and DLP from this location to a similar level with international ones is obvious; the current work showed significant distinction of the CTDIv (5.3% - 26.8%) and DLP (8.4% - 27.5%) from popular works from other authors and/or country (Portugal and EC), as shown in Table 5, although there were still slight variations among them. To achieve a comparable dose levels for patient optimization, synergy should be reached between the practicing radiological professionals (radiologist and CT radiographers) and clinical professionals (physicians).

Conclusion

The study has established the local diagnostic reference levels (LDRL) for adult Head CT scans for the population of Rivers state, south-south, Nigeria as 54.9 mGy and 1103 mGy.cm. These values are therefore similar to recommendations by international bodies as obtained in the studied locations if constant dose auditions are to be conducted.

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