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Estimation of Dose Reference Values for Patients Undergoing Chest and Abdomen Computed Tomography Scan in Sokoto, Nigeria

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Abstract: ***Sokoto state is among the oldest state in Nigeria with history of medical diagnostics, after the establishment of Radiology department in Usmanu danfodio university teaching hospital, number of patient in the radiology department increase year after year and this results the establishment of private diagnostics center in the state. The aims of this study is to estimate a reference dose levels in sokoto for patient undergoing chest and abdomen computed tomography scan and compare the values with the published work values and see if better optimization are practice in sokoto. The study was conducted in two different centres in Sokoto, 60 consenting adult participants (weighing 70 ±10 kg) data was collected from two different center with CT machine model of GE 4-slice and Phillips 16-slice from January to March 2021. For each chest and abdomen scan, patient information, exposure factors, volume computed tomography dose index (CTDIvol) and dose length product (DLP) values were recorded. The data were analyzed using SPSS version (16) statistical software. The mean, standard deviation and 75th percentile values of the CTDIvol and DLP were calculated. An inter-comparison of the measured 75th percentile reference dose values from the two research centres was conducted and compared with the Nigerian published work and European DRL values. The dose reference values reported in 75th percentile values of CTDIvol and DLP in chest and abdomen was 15 mGy and 1205 mGy.cm for chest 20 mGy and 1275 mGy.cm for Abdomen in centre A while 10 mGy and 630 mGy.cm for chest and 16 mGy and 520 mGy.cm for Abdomen in centre B. There is a large variation in doses for chest and abdominal CT examinations between the two centres in Sokoto. The 75th percentile CTDIvol and DLP dose values for these procedures are comparable to those reported published Nigerian work and other European countries and are considerably higher. Therefore dose optimization in Sokoto is recommended.***

Keywords: CTDIvol, DLP, CT scan, and 75th %

1. Introduction

Computed tomography, more commonly known as a CT or CAT scan, is a diagnostic medical imaging test. Like traditional x-rays, it produces multiple images or pictures of the inside of the body. The cross-sectional images generated during a CT scan can be reformatted in multiple planes. They can generate three-dimensional images these images can be viewed on a computer monitor, printed on film or by a 3D printer, or transferred to a CD or DVD. CT images of internal organs, bones, soft tissue and blood vessels provide greater detail than traditional x-rays, particularly of soft tissues and blood vessels. Using specialized equipment and expertise to create and interpret CT scans of the body, radiologists can more easily diagnose problems such as cancer, cardiovascular disease, infectious disease, appendicitis, trauma and musculoskeletal disorders (Brenner & Hall 2007).

Diagnostic reference levels are reference dose levels in medical radio diagnostic practices, for typical examinations, or groups of standard-sized patients or a standard phantom, and broadly defined types of equipment. These levels are expected not to be exceeded, for standard procedures when good and normal practice regarding diagnostic and technical performance is applied (European Commission, 1999). According to council directive 97/43/ Euratom, Diagnostic Reference Levels (DRLs) are dose levels in medical radiodiagnostic practice or, in the case of radiopharmaceuticals, levels of activity for typical examination. The concept of the Diagnostic reference level 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).

Diagnostic reference level at local level in Computed tomography

The new medical exposure regulatory in the UK requires all hospitals to have procedures in place for diagnose a patient particularly in computed tomography which sees as highest radiation dose procedure, for the regular protection of patient and for checking compliance with international DRLs (Wall, 2000). There are basically three options available to establishing DRLs locally.

- They can be either adopt the national DRLs,
- Use regional patient dose data to derive essential regional DRLs.
- Adopt them for local use, or use their own hospital dose data to drive reference levels that are specific to their own practice.

Every procedure applied in establishing local diagnostic reference level most march with the recommended guideline recommends by Europen commission which they state below (Idris 2014)

1) A minimum of twenty (20) patients could be considered per body examination.
2) DRLs for diagnostic radiology should be based on doses measured in various types of hospitals, clinics and practice and not only in well-equipped hospitals.
3) DRLs are only applicable to standard procedures, standard phantom or group of standard-sized patients,

and for specific groups of children distinguished by age, size and weight.

4) For CT, the volume CT dose index ($CTDI_{vol}$) and the dose length product (DLP) are suitable quantities to be used as DRLs.

2. Materials and Method

A prospective quantitative methodology is choice for this study to estimate a reference dose levels for adult patient undergoing chest and abdomen computed tomography in sokoto.

Data collection

A total of 60 patient data was collected from two different center with CT machine model of GE 4-slice and Phillips 16-slice from January to March 2021. Both the centers were chosen because they met the eligibility criteria for the study; having all the imaging modalities for the study and Nigerian Nuclear Regulatory Authority's Requirement for Authorization and Practice (Licensing) involving ionizing radiation. Ethical approval for the study was obtained on 2nd August 2012 from the Research and Ethical committee of the two centres.

Selection of Patient for the study

Adult patient weighted 70±10kg with age between 16-80 years for both male and female since hospital classification age in Nigeria consider 16 years as an adult. A spreed sheet adapted from the United Kingdom CT dose survey sheet was used for data collection. The sheet was designed to extract patient anthropometric characteristics such as age, weight, and gender. A scan parameters such as kV, mA, scan length, and pitch, dose descriptors parameters ware also recorded which are CTDIvol and DLP.

Data Analysis

The data collected were analyzed using a recommended statistical software SPSS version 16.0. Mean mode, standard deviation (SD) and 75% percentile of CTDIvol and DLP was calculated. Were 75% value is chosen as an appropriate investigation level on the grounds.

3. Result

The summary of scan and measured parameters used and record by the two centres under study is presented in the table 1-4 for both chest and abdomen CT scan.

3.1 Result of Scan Parameters

A summary of scan parameters such as kV, mA, Scan length and pitch is presented in Table 1 and 2 for chest and abdomen CT scan for both centres in the under study.

Table 1: Mean, SD and 75th percentile of Chest Scan Parameters

Centres	No. of Patient	kV	mA	Scan length	Pitch
Centre A Mean ± SD 75th Percentile	30	140 (±0.00) 140	244 (±4.98) 250	34.9 (±4.95) 40	0.88 (±0.001) 0.88
Centre B Mean ± SD 75th Percentile	30	120 (±0.00) 120	89 (±7.54) 100	32 (±1.95) 36	0.75 (±0.00) 0.75

Table 1, present the summary of scan parameters of chest CT scan which shows that centre A have highest scan parameters used.

Table 2: Mean, SD and 75th percentile of Abdomen Scan Parameters

Centres	No. of Patient	kV	mAs	Scan Length	Pitch
Centre A Mean ± SD 75th Percentile	30	140 140	236 (±20.9) 250	34 (±3.83) 38	0.987 (±0.03) 1.00
Centre B Mean ± SD 75th Percentile	30	120 120	89 (±6.75) 100	28.9 (±2.56) 30	0.900 (±0.12) 1.00

The summary of scan parameters for abdomen CT scan which shows that centre A have the most uses scan parameters in both Tube voltage (kV), Tube current (mAs), Scan length in (cm) and the pitch factor.

Result of Measured Parameters

Summary of measured parameters are present in Table 3 and 5 for chest and abdomen CT scan, such as weight (kg), CTDIvol and DLP.

Table 3: Mean, SD and 75th percentile values of Chest CT scan

Centres	No. of Patient	Weight (kg)	CTDIvol (mGy)	DLP (mGy.cm)
Centre A Mean ± SD 75th Percentile	30	67 (±8.70) 71	14.5 (±0.63) 15	723 (±233) 1205
Centre B Mean ± SD 75th Percentile	30	66 (±7.5) 70	8.93 (±1.02) 10	397 (95.2) 630

The summary of measured parameters foe chest CT scan shows that centre A have the highest values in both CTDIvol (mGy) and DLP (mGy.cm) and this result from the highest scan parameters used during the examination. Tube voltage and tube current are factors that increase the values of CTDIvol while scan length also result the highest DLP values used by the two the two centres.

Table 4: Mean, SD and 75th percentile values of Abdomen CT scan

Centres	No. of Patient	Mass (kg)	CTDIvol (mGy)	DLP (mGy.cm)
Centre A Mean ± SD 75th Percentile	30	67 (±8.70) 71	18 (±2.28) 20	874 (±244) 1275
Centre B Mean ± SD 75th Percentile	30	66 (±7.5) 70	15.6 (±0.58) 16	413 (±99.9) 520

Table 4, present the summary of measured parameters for abdomen CT scan, which shows that centre A also present the higher values score while centre B also record the values and present by the least values of scan parameters used or employed during the examination.

Table 5: Comparison of Dose values in 75th % with some published Nigerian work values

Research Study	Chest		Abdomen	
	CTDIvol (mGy)	DLP (mGy.cm)	CTDIvol (mGy)	DLP (mGy.cm)
Centre A 2021	15	1205	20	1275
Centre B 2021	10	630	16	520
Ogbole and Obed 2014	22.7	1187	37.9	1902
Kabir M. 2016	10	407	15	757
Enest *et al* 2018	20	1486	17	735

Table 6: Comparison of dose values in 75th % with some European published DRL values

Research Study	Chest		Abdomen	
	CTDIvol (mGy)	DLP (mGy.cm)	CTDIvol (mGy)	DLP (mGy.cm)
Centre A 2021	15	1205	20	1275
Centre B 2021	10	630	16	520
UK 2004	14	580	14	560
United State 2015	17	610	17	860
Canada 2017	13.7	487	23	806

4. Discussion

From this study the 75th percentile values of CTDIvol and DLP for chest in the study centres was 15 mGy and 1205 mGy.cm in centre A while 16 mGy and 630 mGy.cm for centre B, In Abdomen, centre A record 20 mGy and 1275 mGy.cm for CTDIvol and DLP while centre B record CTDIvol of 16 mGy and DLP of 520 mGy.cm repectivelly. When compare the CTDIvol and DLP values of the two centre's with Nigerian published work Centre A, CTDIvol's and DLP's are higher than the two reported published work and less than one in both chest and abdomen scan, while centre B, CTDIvol and DLP is in line with one reported published Nigerian work in chest and less than all the two reported work in chest and abdomen (Table 5). In comparing with European established DRL values, centre A values of CTDIvol's and DLP's is also higher than two reported established DRL values and less than one in DLP values centre A record the higher than all the reported established DRL values, while centre B recorded values in DLP is less than all the reported established European DRL values.

The higher dose reference values in this study may be attributed to the variation in technical parameters, clinical complexity of patients and untimely quality control program in most of our hospitals. There is also a wide variation between the two centres, many factors may be responsible for these dose variations and include differences in technology and scanning protocols across centres. The technology of CT has evolved over the years, and recent innovations in detector technology. The CT systems included in the current study differ in technology and model, with the number of slices per rotation ranging from 4 to 16. The reconstruction algorithms also differ across scanners, and may have contributed to dose variations. Literature shows that the lower CT models such as GE (4 slices) generated higher CTDIvol and DLP compared to 16 slice scanners, with the doses showing a downward trend as the technology improved, and also there is evidence that helical compared to axial scanning is associated with a 3%–14% dose reduction Enest *et al.,* (2018). Most of the data included in this study were acquired in axial modes thus; differences in technology and scanning modes may be partly responsible for the high doses and dose variations observed. Upgrading to newer and more advanced CT technologies may help reduce patient doses in Sokoto. We noted that centres using lower kV and mA consistently demonstrated CDTIvol and DLP values below the published reported values. Variations in scan length were also associated with differences in CTDIvol and DLP respectively.

This suggests that there are opportunities for optimisation of CT examinations through appropriate selection of technical and exposure parameters. This may be particularly relevant for centres with dose values above the published reported work. It should be noted that the 75th percentile dose values reported in this study are not threshold doses or punitive limits, but to provide a benchmark to enable centres compare their dose values to the national standard. Such comparisons may enable centres with dose outliers assess their practice to uncover other contributory factors and trigger optimisation strategies.

5. Conclusion

The dose reference values reported in 75th percentile values of CTDIvol and DLP in chest and abdomen was 15 mGy and 1205 mGy.cm for chest 20 mGy and 1275 mGy.cm for Abdomen in centre A while 10 mGy and 630 mGy.cm for chest and 16 mGy and 520 mGy.cm for Abdomen in centre B. There is a large variation in doses for chest and abdominal CT examinations between the two centres in Sokoto. The 75th percentile CTDIvol and DLP dose values for these procedures are comparable to those reported published Nigerian work and other international countries and are considerably higher. Technological and technical factors appear to be significant contributors to high doses and dose variations. Therefore upgrade in CT technology, optimisation of protocols including exposure and technical parameter selection should help reduce dose variation. Centres with dose outliers, above the reported published work, urgently need to explore as low as reasonably practicable.

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