Nigerian Journal of Medical Imaging and Radiation Therapy

COMPUTED TOMOGRAPHY EXAMINATION IN NORTH EASTERN NIGERIA: RESULTS FROM INTERNATIONAL ATOMIC ENERGY AGENCY'S REGIONAL PROJECT.

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ARTICLE INFO

Keywords:
Diagnostic Reference Levels, Head, Computed Tomography, North eastern Nigeria, International Atomic Energy Agency

ABSTRACT

Objective
The objective of the study was to determine the DRLs for head, chest and abdomen computed tomography examinations in North eastern region of Nigeria

Methods and Materials
Prospective cross-sectional study was conducted in five hospitals among 300 patients referred for head, chest and abdomen CT examinations. Computed tomography dose index (CTDIvol) and dose length product (DLP) were recorded.

Results
The CTDIvol and DLP values observed were 46.68mGy and 1077.72 mGy.cm ; 11.62mGy and 596.52mGy.cm ;21.58 mGy and 968.14 mGy.cm for head,chest and brain CT. Diagnostic Reference Levels were 58mGy and 1470mGy.cm, 12.98mGy and 587.1 mGy.cm and 13.16 mGy and 853.5 mGy.cm for head , chest and abdomen. Comparison of the third quartile dose values with other studies shows that DRL values for CTDI were lower that international values but the DLP was higher.

Conclusion
The main contributor to high dose was the use of different techniques and the used of protocols for adults in some cases by the operators.

Introduction

Diagnostic reference levels were first mentioned by the International Commission on Radiological Protection (ICRP) in 1990 and subsequently recommended in greater detail in 1996 from the 1996 report [1]. The Commission now recommends the use of diagnostic reference levels for patients. These levels which are a form of investigation level, apply to an easily measured quantity, usually the absorbed dose in air, or in a tissue equivalent material at the surface of a simple standard phantom or representative patient [2]. The diagnostic reference level is intended for use as a simple test for identifying situations where the level of patient dose or administered activity is unusually high. If it is found that procedures are consistently causing the relevant diagnostic reference level to be exceeded, there should be a local review of procedures and the equipment in order to determine whether the protection has been adequately optimized. If not, measures aimed at reduction of dose should be taken [3]. DRLs is an optimization tool to ensure patients are adequately protected and it is deemed to be an important mechanism for the management of patient dose to ensure it is commensurate with the medical purpose of x-ray examination [4]. In the recommendation of international commission of Radiological protection (Report 103), the principle for setting DRLs are enumerated, the local, regional and national objectives is clearly defined, including the degree of the specification of clinical and technical conditions for medical imaging task, the selected value of the DRL is based on the relevant regional, national and local data, the quantity used for the DRLs can be obtained in practical way [1]. Diagnostic Reference level is specific to different imaging modality that makes use of ionising radiation. Diagnostic reference levels (DRLs) have been an essential tool in the International Commission on Radiological Protection's (ICRP's) radiological protection armamentarium. Diagnostic reference levels according to ICRP is a term used as a form of investigating radiation level used to aid in optimization of protection in the medical exposure of patients for diagnostic and interventional procedures [1]. DRLs are not dose limits for individual patient examinations but serves as an optimization tool in medical radiation protection. They are used to identify those situations in which, for a specific radiological procedure, unusually high or low doses necessitate optimization actions [5].

Computed tomography (CT) is a widely used and valuable imaging investigation that provides medical benefit in clinically justified situations [6]. The technological advances in computed tomography (CT) scanners have resulted in its recognition as a valuable diagnostic tool by many medical practitioners [7]. DRLs have been proven to be a valuable tool in reducing large differences in CT radiation doses between different radiological facilities. The European Commission launched the EUCLID (European study on clinical DRLs for x-ray medical imaging) project in August 2017 to provide up-to-date clinical DRLs for x-ray medical imaging [8]. For the purpose of optimization in radiation protection, dose delivered to patients during diagnosis is studied with assessment of image quality [9]. This is a common practice in many parts of the world who present with clinical cases requiring x-ray examination which are often times not properly done and this is largely due to lack of facilities and suitable qualified personnel, as a result, there is no sufficient information about patient's radiation dose [10].

Radiation dosimetry is required to assess the risk associated with x-ray exposure and to inform medical radiation professionals of the levels of exposure received [11].

In the absence of an established local or national dose levels, typical dose levels obtained should be compared with published DRLs of similar practice. Published DRLs is useful when comparing the median dose values in a facility for a particular imaging system. Published DRLs values from other countries may not be relevant to all due to different imaging practices and technology in use in different parts of the world; however, it serves as a guideline for establishing or comparing local and national DRLs for patient dose optimization. Technological advancements such as post-processing and iterative reconstruction in CT should be taken into consideration when updating DRLs. DRLs should be set in terms of the practical dose quantities used to monitor practice. These dose metrics should be easily measurable. European countries have a high prevalence of DRLs survey [12].

In Nigeria, there is no known set local or national rule for DRLs; however, studies have been carried out on the establishment of DRLs based on anatomical regions.

In order to ensure optimisation of protection, image quality or the diagnostic information provided by the examination (including the effects of post-processing), must be evaluated. The concept and proper use of DRLs should be included in the education and training programmes of the health professionals involved in medical imaging with ionising radiation. The ICRP recommends that DRLs should not be used to evaluate medical imaging tasks where the relative tissue dose distribution in the body is appreciably different from that of the medical imaging task used to establish the DRL. This study is an excerpt of the International Atomic Energy Agencies Regional meeting on establishing DRLs for CT examination and quality control of CT equipment in African member states with 10 countries in representation and the aim is to establish a standard protocol from ICRP pubication 135 on DRLs as a prelimnary data in Nigeria and IAEA.

Materials and Methods

The study is a prospective cross sectional study conducted in five major referral hospitals in North eastern Nigeria. A total of 300 patients consented for the study after we have obtained ethical approval from the hospitals. Standard weight of 70±5 kg was adopted for the study. In line with

Helsinki declaration (1964), ethical approval was obtained from the research ethics committee. Informed consent form interpreted in Hausa language was filled by each (volunteer, Patient) participant in compliance with the human research ethics guidelines for patients who do not understand English Language. Only adult male and female patients from 18 years and above referred for CT examinations in each hospital under study. Standard IAEA data capture sheet was adopted and data will be acquired from machines that have quality control and quality assurance program in place. Computed tomography dose index (CTDIvol) and dose length product (DLP) was obtained for Head chest and Abdomen without contrast from the monitor of the CT machine directly. Scan parameters such as tube current (mAs), tube voltage (kV), slice thickness, pitch, scan length, number of slices scan mode and field of view (FOV) were also displayed on the monitor. Mean, median and maximum value of each facility was calculated using Microsoft excel and Statistical package for social science (SPSS) version 25.0 Chicago. Diagnostic reference levels (DRLs) was calculated as 75 percentiles (3rd Quartile) value of the distribution of doses obtained.

Table 1: Diagnostic Reference Levels for head, chest and abdomen Computed Tomography

	Head		Chest		Abdomen	
	CTDI (mGy)	DLP (mGy.cm)	CTDI (mGy)	DLP (mGy.cm)	CTDI (mGy)	DLP (mGy.cm)
Min	25.66	402.4	2.96	591.34	6.64	278.76
Mean	46.68	1077.72	11.62	596.52	21.584	968.14
Median	43.53	1106.9	10.521	542.42	11.758	715.78
Max	99.328	1779.44	38.72	1751.64	70.268	2580.14
DRLs	58	1470	12.9	587.1	13.6	853.5

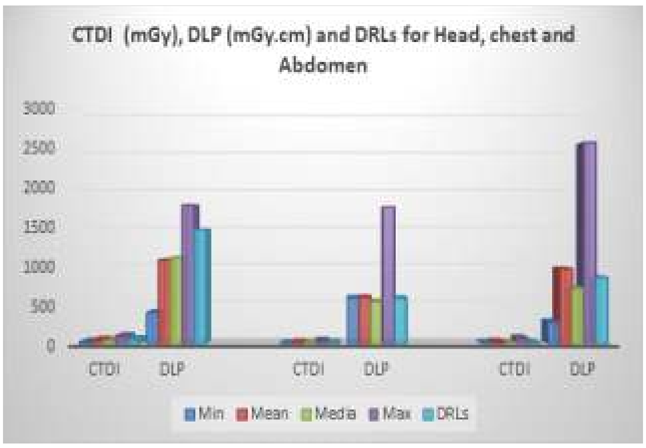

Figure 1: DRL values for CTDI and DLP in the five hospitals

Discussion

Computed tomography imaging has been recognized as a high radiation dose modality, when compared with other diagnostic techniques using ionizing radiation. This has raised concern over patient radiation doses [15]. It has been estimated that CT examinations make up approximately 11% of all radiological procedures and that radiation from CT delivers approximately 70% of the medically-related radiation dose and approximately 6% of CT examinations were performed on children under the age of 15 years [15]. The existence of risk to patients following exposure during CT examinations remains controversial. The lifetime attributable risk of a fatal cancer from all causes is 22.8 %, whereas that associated with ionizing radiation exposure from a typical CT is 0.05 % [16]. Therefore, sensible use of the modality requires strict adherence to the tenets of radiation protection measures such as justification, optimization and minimization to ensure that the risk to patients does not outweigh the benefit gained from the technique [17].

This study revealed the estimated CTDIvol and DLP of adult patients undergoing head CT, chest and abdomen scans in different centers within North eastern part of Nigeria. Local diagnostic reference levels were established based on different anatomical region taking into cognizance standard size patients of 70 ± 5 kg. In addition, factors responsible for CTDIvol and DLP variation between centers are investigated and discussed. This study shows enormous variations between the different centers in reported local DRLs. The reason for these variations is in line with many DRL studies which are mainly attributed to different exposure parameters and radiographic technique. This shows that there is a wide gap in optimization of practice among amongst all the centers. Considerable reduction in dose delivered during CT scan procedures can be achieved if optimization is adopted by ensuring that examination protocols exceeding the study's third quartile are adjusted and then reviewed [18]. Radiation dose during CT scanning depended on many factors, including patient characteristics, exposure factors, scan parameters and operator competency.

The mean CTDI and DLPs for head CT in the hospitals were within 46 to 63 mGy and 1070 to 1760 mGy.cm except for hospitals D and E with 480 to 510 mGy . The variation could likely be due to different equipment make up and operator protocol applied during examination. The total mean There were no variation in the CTDI and DLP value for chest and abdomen CT.

This investigation revealed an observable change in CT practices, with a much wider range of studies being performed regularly. This reflects the improved capacity of CT scanners to scan longer distances and at finer resolutions as permitted by helical and multislice technology [19]. The mean computed tomography dose index for head in this study is lower (50±10 mGy) than the study done in Abuja North Central Nigeria by Abdullahi *et al.,*2015 and Muhammad et al., 2016 with (52.2mGy) CTDI of head in North cental Nigeria, but higher than the study done by Saravanakumar *et al.,* 2014 with head CTDI of the 32mGy respectively. However, the values were lesser than the study by Santos *et al*., 2013 in Portugal which presented a value of 75mGy for head CT and a value of 65mGy for a study done by Treier et al.,2010.[20].

The DRL for Australian radiation protection and nuclear safety agency (ARPANSA) for CT were 47mGy, 9.5mGy and 10.9mGy for CT head, chest and abdomen respectively. That of European commission was 60mGy, 30mGy, and 35mGy for head CT, chest CT and CT abdomen respectively. Similarly, UK values were 66mGy, 17mGy and 19mGy for CT head, chest and abdomen respectively. The DRL values obtained in this work were 58 mGy, 12.9mGy and 13.16 mGy for head CT, Chest CT and CT abdomen respectively. The DRL obtained in this study is lower that the value obtained in UK and the European commission. However, there was significant reduction when compared to the previous study in Northeastern Nigeria with a value of 68mGy higher when compared with the reported values for ARPANSA, European commission and United Kingdom [21]. The findings in this work disagrees with a similar study by Abdullahi *et al.,* 2016 in North central Nigeria with a value of 38.0mGy lower than European commission [22]. The DRL for head CT obtained in this work is lower than the value obtained in another study in Nigeria by Garba *et al.,* 2014 and Ogbole and Obed, 2014 with DRL values of 79mGy and 73.5 mGy respectively [14, 23]. Although this study may not be a representation of what happens in every hospital but it is an indication that a considerable optimization potential of CT practice through standardization of medical imaging protocols and etiquette. The higher dose received for DLP in this study is attributed to variation in technical parameters, clinical procedures, radiographic technique, untimely quality control program and perhaps the condition of the CT machine. The UK study, ARPANSA study and EC study are better means of comparing with this study because its values were obtained from a survey of multi- slice CT scanners. However, result of comparison suggests the need for optimization of doses for more hospitals in Nigeria. The resultant DRL value based on exposure parameters were found to be lower than the ARPANSA and UK but lesser when compared with EU values for CT chest and Abdomen respectively. Lower DRLs could be due to the fact that hospital and technique vary in their operation and specifications. In some cases authors setting up DRLs do not report on the patient dose influencing factors like added filtration, screen film speed, generator type, and use of automatic exposure controls manual method and image receptor technology.

Conclusion

The study established DRLs for computed tomography examination to be 58 mGy and 1470 mGy.cm, 12.93 mGy and 587.1 mGy.cm and 13.16 mGy and 853.5 mGy.cm for CT head, CT chest and CT abdomen. The CTDI values were lower compared to other countries but d DLP was high. The major contributor to high dose in this present study is attributed to patient size, clinical complexity, sub optimal usage of equipment or equipment problems mainly as a result of the paucity of regular quality control and effective implementation of radiation protection program in our health care facilities. The present work has demonstrated that an efficient and fully integrated radiological dose information system can play an important role, providing data to support radiologist, radiographers, medical physicist, academicians, professional bodies and regulatory bodies in adopting the best strategy in ensuring that radiation doses to patients are adequately optimized. This study has an educational and regulatory function to the radiology and radiation protection community and furthermore provides a benchmark to assist any statutory organization to establish DRLs for diagnostic radiology practices in Nigeria, Africa and the world entirely.

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