Evaluation of Computed Tomography doses in three medical diagnostic centres in Kano

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Abstract

Computed tomography (CT), is an X-ray procedure that generates high quality cross-sectional images of the body, and by comparison to other radiological diagnosis, the use of CT in medical diagnosis delivers radiation doses to patients that are higher than those from other radiological procedures. Lack of optimized protocols could be an additional source of increased dose in developing countries. The aim of this study is to conduct radiation doses survey for head, chest and abdomen CT examinations of patients in three selected CT Diagnostics centers in Kano city. Detailed were obtained for 144 CT examinations for adult patients only. The results from the three Diagnostics centers (hospitals) were compared with each other as well as with the IAEA guidance level for this particular investigation. Survey of radiation doses were carried out by calculating Volume dose index (CTDIvol), and dose length product (DLP) using the SPSS software program. The study showed that the mean DLP of the one Diagnostics center (hospital) is 1522.6 mGy.cm which is far much higher than the two other diagnostic centers Mohammed Abdullahi Wase which stands at 661.0 mGy.cm, Providian medical diagnostic center which stand at 1121.3 mGy.cm as well as higher than the IAEA level which is 527 mGy.cm. The study showed that the mean CTDIvol for patients in AKTH is 38.6 mGy which again is higher than the two other diagnostic centers Mohammed Addullahi Wase which is 9.5 mGy, Providian medical diagnostic center is 9.6 mGy though, it is less than the IAEA level which is 47.0 mGy.

This study showed that there is an urgent need for optimizing patient doses in Kano city CT examinations. This can be ensured by providing training and retraining for workers and conducting quality control measurements and preventive maintenance regularly so as to detect any unnecessary outflow of ionization radiation early enough before they negatively affect the image which may necessitate re-imaging and then increase patients' dose.

Keywords: periodic motion, complex-valued system, asymptotic analysis, parametric resonance.

Background of the study.

Computed tomography (CT) is a non-invasive method of acquiring the images of the inside of the human body without superimposition of distinct anatomical structures. The images are formed from a mathematical reconstruction of x-ray attenuation measurements made through a thin axial slice of the patience (Garba, 2014). In CT, the x-ray tube rotates around the body, making multiple exposures at different angles that allow the computer to generate detailed images of the patience's anatomy.

Application of radiation in medicine could be with ionizing or non- ionizing radiation (IAEA 2002; NNRA 2003). The use of ionizing radiation in medicine is of great concern since it could cause harmful effect to the body. The radiation doses delivered to the patients, personnel and the public during Computed tomography (CT) examination should be of radiation protection concern owning to non-uniformity in dose distribution and radio-sensitivity of different anatomical structure (Akinlade *et al.*, 2012; NCRP 2004). Computed tomography (CT) radiation imaging is a high source of radiation exposure, (UNSCEAR 2008, NCRP 2004,). It is of great necessity that the radiation dose in computed tomography should be evaluated to reduce the over exposure or under exposure of patient during CT imaging (Sungita, 2006).

Despite the revolution in modern diagnostic imaging and analysis in medicine, the advent of modalities such as computed tomography (CT), can produce extremely detailed images by creating cross sectional images of high radiographic contrast of any part of the body in seconds. Many somatic effects of radiation could also be found evident a few months after the use of the X-ray in diagnostic medical application (UNSCEAR 2008; NCRP 2004). And assessment of the radiation risk should be based on organ doses or effective dose, according to International Commission for Radiological Protection (ICRP, 1996). Presently, radiation imaging and treatment are the largest source of medical radiation exposure, consisting of half of the total medical exposure (NCRP 2004). This may impose some radiation dose that is too risky to ignore. Two obvious diagnostic imaging techniques that expose the patient to high radiation doses are the head and abdominal computed tomography (NCRP 2004).

Computed tomography is an x-ray based procedure that generates high quality cross sectional images of the body without any limitation on the imaging plane or field of view (FOV). It accounts for approximately 6% of all medical x-ray examinations and contributed 41% of collective dose in 1999- 2004 (UNSCEAR 2008).

Hartz (2004) maintains that, CT examination form 9% of all medical x-ray examinations and 47% contribution to resultant collective dose in 2003-2004. Presently, CT accounts for up to 15% of the x-ray medical examination and 70% resultant collective dose (Sungita, 2006).

Computed tomography (CT) was introduced into clinical practice in 1972 and had revolutionalised x-ray imaging by high quality images which reproduced transverse cross sections of the body (European Guideline, 2014). The technique offered improved low contrast resolution for better visualization of soft tissue, with relatively high absorbed radiation dose. The initial potential of the imaging modality has been realized by rapid technological developments, resulting in the continuing expansion of CT practices. As a result, the numbers of examinations are increasing to the extent that CT has made a substantial impact on not only patients care but also patients and population exposure from medical x-ray. Today, it accounts for up to 41% of the resultant collective dose from diagnostic radiology in some countries of the European Union (EU). 1999- 2004 (UNSCEAR 2008).

Special measures are consequently required to ensure optimization of performance in CT, and of patient's protection (European Guidelines, 2014). It was estimated that more than 62million CT scans per year are currently obtained in the United States (Brenner & Hall, 2017).

The two basic principles of radiation protection for medical exposure as recommended by ICRP are justification of practice and optimization of protection, including the consideration of diagnostic reference levels. The emphasis is to keep dose to the patient as low as reasonably achievable (ALARA), consistent with clinical requirements.

Justification is the first step in radiation protection and no diagnostic exposure is justifiable without a valid clinical indication. Every examination must result in a net benefit for the patient. Justification for CT also implies that, the required result cannot be achieved by other methods which are associated with lower risks for the patient. Ultrasound and MRI offer alternatives to CT in many areas of application.

In respect of radiological examinations, ICRP draws attention to the use of diagnostic reference levels as an aid to optimization of protection in medical exposure. Once the diagnostic examination has been clinically justified, the subsequent imaging process must be optimized. The optical use of ionizing radiation involves the interplay of three important aspects of the imaging process; diagnostic quality of the image, radiation dose to the patient and choice of examination technique.

Statement of Problem.

CT examination have been described as a high radiation dose procedure, and the CT head, chest and abdomen, are the most common examination in the radiology department in most countries. Diagnostic reference level helps to identify situation where unnecessary radiation dose is used for diagnosis. As such, it has been recommended by the international organization such as international Atomic Energy Agency (IAEA) that every country should establish their dose reference level. However, in Nigeria, there is no national dose reference level establish for CT procedure. Therefore, this study intends to start with local dose reference level LDRL with a view to establish national dose reference level NDRL in the future.

Questions

1. What are the radiation doses for most of chest, head, and abdominal CT examination in Kano?
2. Are there any significant variations between the radiation doses gotten from the three centers due to the use of different machines?

Research methodology

Methods.

This study adopted a prospective and quantitative research design to determine the absorbed radiation dose to patients undergoing CT scan of head, chest and abdomen. A quantitative design was appropriate because the study involved the use of numerical data, and was conducted prospectively to ensure more reliable and valid data (Punch, 2006). Acquired from the computer monitor screen, where dose report and parameters can be stored and retrieved if need be.

Sample Size

Sample sizes of 180 participants (adult patients) were recruited for head, chest and abdominal CT scan examination from the three medical diagnosis centers. This was obtained through careful selection of suitable adult patients with not any cancerous case or any anatomical mutation. 20 adult are participants each from the three centers (Aminu Kano Teaching Hospital Center (A), Muhammad Abdullahi Wase Specialist Hospital center (B) and Providian Medical Diagnosis center, center (C) that came for head CT examination.

In the chest CT examination, a sample size of 60 participants was obtained in the study. This was done through selection of -20- participants from center A, -20- participants from center B and -20- participants from center C

In the abdominal CT examination, similar techniques sampling method was employed. -20- Suitable participants each from center A, B and C were considered for this study.

In case of variation in the sample size due to limitation of suitable participants in the study centers, purposive sampling technique will be consider to best harness the data (tongco,2007; Garba, 2014).

Based on the recommendation guideline for sample recruitment made by the European commission (EC) which says a minimum of 10 participants shall be recruited for each body part under examination (European commission, 1999). Furthermore, the larger a sample, the more representative it will be of the population from which it has been taken. (Willis, 2004, Garba, 2014). For this study, not all patients that met the inclusive criteria and agree to participate in the study were weighed to be sure they are within the weight limits of standard size patient which is 70± 3 kg for the European population (European commission 1996). Reasons had been that not all centers have a weigh balance machine and more also that not all patients that met the inclusive criteria and agree to participate in the study could stand erect at that material point in time.

From the result obtained above, Heat CT at center (A) has the highest CTDIw, value followed by center (B) and Center (C) with 62mGy, 35mGy, and 19 mGy respectively. Meanwhile, the highest DLP value were noted at center (A) then center (B) and center (C) as 3351mGy*cm, 574mGy*cm and 643mGy*cm respectively.

For the chest CT, center (B) has high CTDIw value as 10mGy followed by center (A) as 9mGy, and the DLP was also high with 642mGy*cm followed by 682mGy*cm from center (B) and center (A) respectively, center (C) has no available data for both CTDIw and DLP values during the study period.

In abdomen CT, center (B) has high CTDIw value as 12mGy followed by center (A) as 10mGy, then center (C) has 7mGy then center (A) happened to be highest in terms of DLP values of 2113mGy*cm followed by center (B) and (C) with 637mGy*cm, 614mGy*cm respectively. The reason for high DLP values in center (A) is because of the high mAs and kV used during the CT examination. And the scan parameters and the protocol used were the main contributors to this higher output particularly, the tube current and the tube potential.

Result and discussion

Question 1: What are the radiation doses for most of Head, Chest, and Abdominal CT examination in Kano?

TABLE 4.5 Measured CTDIw and DLP values from the study centers

Centers	Region	CTDI (mGy) Mean ±SD	DLP (mGy) Mean ±SD	75th Percentile (3rd Quartile)
Center A				
	Head	62.8±1.3	3006.0±888.3	62 3351
	Chest	5.2 ±3.3	510.2± 357.8	9 682
	Abdomen	9.1±5.0	1995.4±1351.6	10 2113
Center B				
	Head	34.7±9.9	545.2 ±87.4	35 574
	Chest	9.2±1.3	576.1 ±91.8	10 640
	Abdomen	10.3± 4.4	523.7	12 637
Center C				
	Head	19.8± 18.1	487.4±193.2	19 643
	Chest	NA	NA	NA
	Abdomen	6.4±1.9	571.9±120.9	7 614

NA=Not available

Question 2: Are the radiation doses for CT scan procedures comparable with established data in the literature?

TABLE 2: Comparison of DRLs in terms of CTDIw (mGy) with the international value

Region	This study 2019	European Commission	Portugal	Australia
Author		European Union, 2014	Santos et al. 2014	ARPANSA 2013
Head	38.6	60.0	75. 0	47.0
Chest	9.5	10.0	14. 0	9.5
Abdomen	9.6	35.0	18. 0	10.9

TABLE 3: Comparison of DRLs in terms of DLP (mGy*cm) with the international value

Region	This study 2019	European Commission	Portugal	Australia
Author		European Union, 2014	Santos et al. 2014	ARPANSA 2013
Head	1522.6	1000	1010	527
Chest	661 .0	600	470	447
Abdomen	1121.3	800	800	696

Conclusion

Diagnostic reference levels were primarily introduced to avoid situations of high patient absorbed radiation dose (Garba, 2014). Furthermore, the CTDI's and DRL's should not be exceeded when departments operate under normal diagnostic and technical practices (ICRP, 1991). The aim of this study was to establish a local diagnostic reference level for routine head, chest and abdomen CT scan in Kano city for the purpose of dose optimization.

The CTDI and DLP evaluation was done following EC guidelines. However, a variation of CTDI and DLP for the same procedure was observed from one Centre to another. This is due to the application of different scan protocols at each of the Centres. The reason the CTDIw was higher than in other studies is due to a high tube current and tube current time product being employed.

Recommendations

Although the CTDIw and DLP values for head and chest was generally higher in Centre (A)and (B) and lower in Centre(C) as compared with published results from other countries, these are the recommended initial LDRLs for Kano city. It is therefore recommended that the tube current time product be investigated and reduced where possible in order to reduce the absorbed radiation dose, and that the protocol for head, chest and abdomen CT is harmonized across all CT centers in Kano city. The final recommendation is that an audit should be conducted in two (2) years' time to establish revised LDRLs that should be lower than these initial recommended doses and equal or similar to the internationally established DRLs.

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