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ORIGINAL RESEARCH ARTICLE

Assessment of Organ Dose and Effective Dose from Head Computed Tomography in Northwestern Nigeria

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ABSTRACT

The amount of radiation dose received by patient undergoing Head computed tomography examination in General Amadi rimi orthopedics and specialist hospital, Katsina has been estimated. Computed tomography dose output was used to determine the effective dose and organ dose of non-contrast to the head region of 30 patients. The tube potential ranged from 127 kVp to 130 kVp, while the mAs ranged from 130 mAs to 140. The aims of this study are, first, to assess the mean effective doses received by patients undergoing Head CT examinations and compare them with other studies. Mean values of CTDIvol. was (43.1mGy), the mean DLP values was (1206 mGy.cm), the mean effective dose ($H_{E,DLP}$) value was (2.4 mSv). The result was compared with the European Union reference dose level and other published factor. $H_{E,DLP}$ was slightly higher than the values reported from the literature for the united nation and European union report by 0.4 factor. It was concluded that patient organ doses could be substantially minimized, optimized and justified. The high variation in the doses in this study may be due to differences in imaging protocols such as large range of mAs and scan length and also algorithms of the scanner.

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Computed tomography, Effective dose, Dose length product, Computed tomography dose index.

INTRODUCTION

Ionizing radiation has been the major source of concern since the introduction of x-ray mammography and computed tomography examination which makes the use of x-rays to obtained the anatomical structure of internal parts of the body and considered the largest contributor to radiation exposure of the society, as such making diagnostic medical x-ray the largest man-made source of ionizing radiation exposure (NCRP, 2009).Despite its large amount of ionizing radiation contribution to medical radiation exposure., The difference of computed tomography over conventional radiography is on the basis of the fact that

1) It has the capacity to remove organ or structural super-Imposition that are mainly occurs in conventional radiography.

2) As a digital medical imaging modality, it has the capacity and potential of producing a clear picture with almost unlimited radiation doses once the detector is linear over the long distance.

3) It has a clear and better cortical definition and readily display calcification unlike MRI (George *et al*, 2016).

The continues increase in computed tomography for diagnostic imaging modality is well documented; likewise the associated increase in radiation risk for patient undergoing head CT examination (Rehani and Berry, 2000).

The recent increase of ionizing radiation in diagnostic imaging modality rapidly expanding use in the emergency setting, the introduction of multi –detector CT units had newly reported concern related to human detrimental effect of low level radiation exposure have revitalized a long – standing concern over the quantification and management of an individual cumulative medical radiation exposure (Brrington *et al*, 2004).

Studies have shown that many physicians including radiologist have misunderstood that the mild imaging acquisition times have resulted in lower doses of radiation,

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when in fact, many times, the opposite is true. Parts of that there is small theoretical risk of carcinogenesis attributable to low doses of ionizing radiation based on epidemiological evidence at higher and dose rate. Researches have proved that there's correlation between the radiation exposure and cancer risk, Epidemiological studies such as life span study of the atomic bomb survivors, medical studies and experimental research have established a relationship between exposure, cancer induction and cellular damage .However, there is consensus on the effects of radiation at low doses and low dose rates, with the linear non threshold hypothesis being widely accepted and the basis of the international system of radiation protection (ICRP, 2007).Tissue reaction effects have exact radiation dose thresholds which increase radiation risk in relatively high doses (ICRP, 2007).

Globally, it is estimated that approximately 3.6 billion diagnostic examinations and 6 million therapeutic treatments are performed annually (UNSCEAR, 2010). Primarily, the people exposed to ionizing radiation for medical purposes are the patients themselves. These exposure situations are deliberate and voluntary with some diagnostic or therapeutic health benefits to be gained. Recent figures show that diagnostic medical exposures, including radiology and nuclear medicine, account for about one-fifth of the average annual output dose to the global population from all sources (ICRP, 2007). The harmful effects of radiation associated with ionizing radiation can be classified as either deterministic (effect of radiation has a threshold to cause damage) or stochastic (no radiation threshold is necessary to cause damage). There is irrefutable evidence from epidemiological studies that ionizing radiation exposure at high doses likely associated with an increase in cancer incidence and morbidity (ICRP, 2007).To accurately examine the associated radiation-induced risks, knowledge of doses to the specific region or organ is recommended in the determination of the probability of inducing any deterministic effects or corresponding stochastic risk of carcinogenesis and genetic effects (UNCEA, 2013). CT scanning of the head is typically used to diagnose infarction tumors, calcifications, hemorrhage, and bone trauma (Galloway, 2015). Of the above, hypo dense (dark) structures can indicate oedema and infarction (Tse *et al*, 2015). Hyper dense (bright) structures indicate calcifications and accumulation of blood and bone trauma can be seen as disjunction in bone windows (Saleh and Kassas, 2015). Tumors can be detected by the swelling and anatomical distortion they cause, or by surrounding Oedema (Khan and, Henderson, 2013). Ambulances will equip with small bore multi-slice CT scanners respond to cases involving stroke or head trauma. CT scanning of the head is also used in CT-guided stereotactic surgery and radiosurgery for treatment of intracranial Tumours, Arteriovenous malformations, and other surgically treatable conditions using a device known as the N-localizer (Brown *et al*, 2012) The most standard method for assessing organ absorbed doses can be performed in two ways; either by direct measurement in patient using dosimeters such as thermo luminescent dosimeters (TLDs), or a phantoms using either an ionization chamber or TLDs. Organ doses can be determined through indirect measurement using measured computed tomography dose index (CTDI) and published conventional factors, obtained from Monte Carlo simulation and mathematical phantom (Sulemana *et al*, 2020).The determination of effective dose, in diagnostic radiology examination is an important method for risk estimates from medical exposure. This is the most recognize reported measurement (ICRP, 2007). In addition ,effective dose allows comparison across the different types of CT studies and also between CT and other imaging test, facilitating comparison of CT to the most accepted radiology examination that patient may undergo. The effective dose account for the amount of radiation to the exposed organs and organ sensitivity to developing tumors from exposure to the radiation.as such, the benefit gain by patient should outweigh the associated risk when imaging is properly done. This study, therefore aim to assess how much radiation exposure has been received by patient undergoing head CT examination at Amadi Rimi othorpaedics and specialist hospital.

MATERIALS AND METHODS

This study involve 30 patient both children and adult of mixed gender referred for head CT scan at Amadi rimi othorpaedics and specialist hospital. Their ages ranges from 1year to 70 years. Ethical approval was obtained from the local ethics committee of the hospital. Computed tomography examination of the head was the most frequently requested examination at this hospital, therefore, scan- specific parameter for this examination were collected. Displayed CT console measurement of CTDIvol and DLP along with records of each patients scanning parameter were obtained from the Soma tom 64 slice CT equipment used at the hospital. Organ and effective dose was calculated mathematically using the DLP obtained from the machine console output multiplied by conversion co-efficient (0.0024) that is Effective Dose = DLP × Conversion coefficient. For the head scan region, the following parameters were obtained from the CT scanner used; tube volage, tube current, scan length ,rotation time , collimation and DLP. The tube potential ranged from 130mAs to to 240mAs, while the kVp ranged 80kVp to 140kVp.The mean exposure parameters used for the examinations under study are presented in Table 2.0.

RESULTS AND DISCUSSION

The assessment of effective dose ($H_{E,DLP}$) from head computed tomography examination at radiology department of General Amadi Rimi othorpaedic and Specialist hospital, Katsina was determined indirectly ($H_{E,DLP}$) from the CT machine console. In this investigation ($H_{E,DLP}$), a total of thirty patients of both genders was referred for brain CT examination. The mean absorbed dose was 7.525mSv, range from (1.03-21.64) mSv and the mean effective dose ($H_{E,DLP}$) was 2.41±0.47 mSv. The tube voltage ranges from 80 - 140Kvp,pitch 1mm,tube current product ranges from 130 -240 mAs, the field of view (FOV) 256mm and scan length 60cm, maximum CTDIvol and DLP was 60.75mGy and 1913mGycm respectively.

Table 1.0 Show the present study of mean value of Computed tomography dose index (CTDIvol).

CTDIvol.(mGy)	CTDIvol.(mGy)	$H_{E,DLP}$(mSv)
43.1	1206	2.4

The above table indicate computed tomography dose index CTDIvol.(mGy),Dose length product(DLP) and mean effective dose $H_{E,DLP}$(mSv).

Table 2.0 Show the CT Machine specification employed in these studies.

S/N	Parameter	CT Machine
1.	Machine Type	64 Slice soma tom
2.	Manufacturer	Siemen
3.	Year of manufactured	2018
4.	Country Manufactured	India
	TUBE READING	
5.	Power	70KW
6.	Maximum KVp	140V
7.	Maximum mAs	580 Ma
8.	Common KVp	130v

The able above indicated different machine specification ranging from model (64 slice soma tom), power capacity (70KV), maximum Kilovolt Power etc.

Table 3.0 Comparison of Dose length product (DLP) and Computed tomography dose index (CTDLvol) with present study and other studies.

	DLP(mGycm)	CTDI $_{VOL}$(mGycm)	LOCTION	YEAR
Present study	1206	43.1	Nigeria	2022
Abdulkadir *et al.*	1024	60.5	Nigeria	2016
Mary-ann *et al*	2102	86.6	Nigeria	2018
Inkoon *et al.*	393	51.0	Ghana	2012
Shrimpton *et al.*	930	100	United Kingdom	2003
Tsapake *et al.*	527	47.0	EU	2006

Table above show comparison of both dose length product (DLP (mGycm)),and Computed tomography dose index (CTDI VOL(mGycm) from this study with Adulkadir et al.,(2016), Mary-ann (2018),Inkoon et al,(2012),Shrimpon et al,(2003), and Tsapake et al,(2006).Both the dose length product (DLP) and Computed tomography dose index(CTDI) from this studies were found to be lower than the rest of the finding, as such the dose was justified and optimized.

Table 4.0 Comparison of Brain mean effective dose ($H_{E,DLF}$(mSv)) with local and international studies.

STUDY	YEAR	LOCATION	$H_{E,DLF}$(mSv)
Present Study	2020	Nigeria	2.4
Abdukadir *et al.*	2016	Nigeria	1.7
Mary-ann *et al.*	2018	Nigeria	6.6
Adejoh *et al*	2015	Nigeria	3.1
Aldrich *et al.*	2016	Columbia	2.8
UNSCEAR	2008	United nation	1.6
EU Report	2014	Europe	2.0

The above table show comparison of the mean effective dose ($H_{E,DLP}$) from this study with the value obtained Abdulkdir et al.,(2016), Mary-ann et al (2018),Christian et al.,(2015),Aldrich et al ,.(216),UNSCEAR .,(2018), and

EU.,(2014).The effective dose ($H_{E,DLP}$) was slightly higher than the values reported from the literature for the united nation and European union report by 0.4 factor. It was concluded that patient organ doses could be substantially minimized, optimized and justified. The result from the present work below the effective dose obtained when compared with the works of Ekpo et al, (2018) who proposed national DRLs for Nigeria

The above table indicate computed tomography dose index CTDIvol.(mGy),Dose length product (DLP) and mean effective dose $H_{E,DLP}$(mSv).

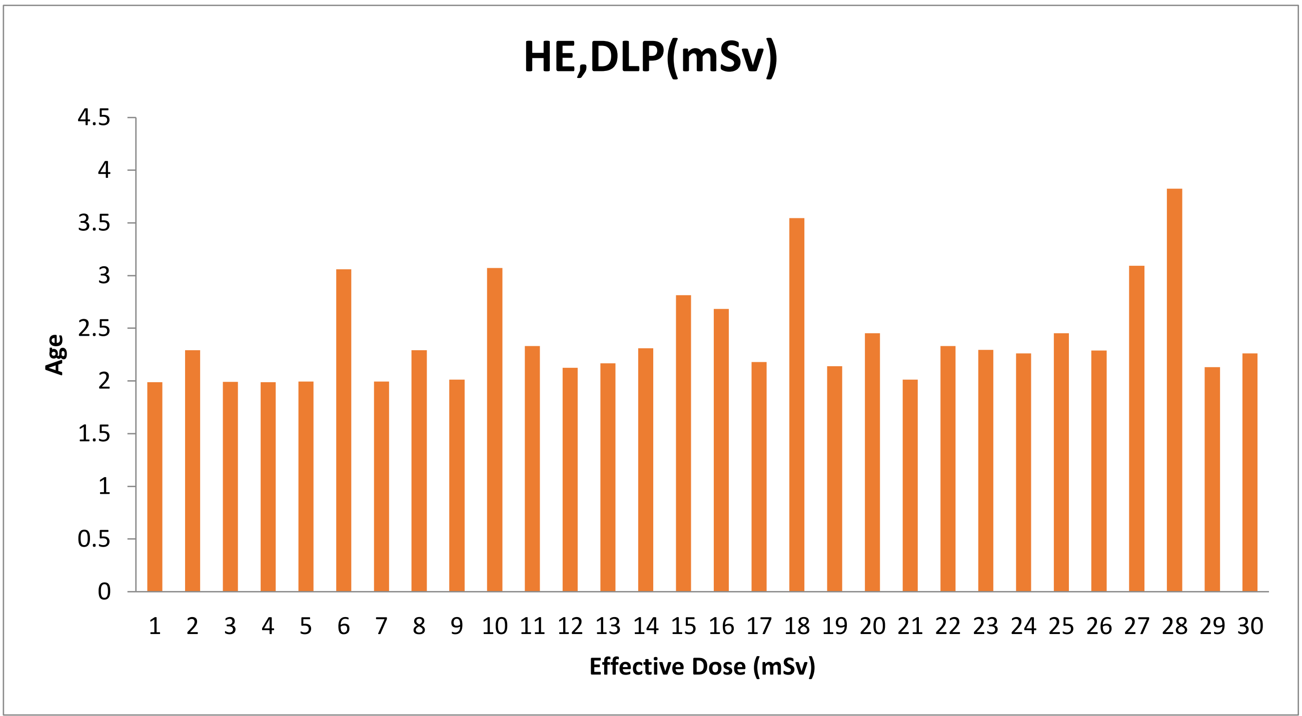

Figure 1.0 Show Brain effective dose ($H_{E,DLP}$(mSv))

Figure above show mean effective dose HE,TLD(mSv) of 2.4mSv,the highest value was 3.8mSv minimum value was 2.mSv.

CONCLUSION

From the two different methods used in this study for assessment of head patient dose, The demonstrated methods can be a reliable means for patient dose monitoring, as long as the computed tomography system work within the accepted diagnostic reference level (DRLs).

$H_{E,DLP}$ was slightly higher than the values reported from the literature for the united nation and European union report by 0.4 factor. It was concluded that patient organ doses could be substantially minimized, optimized and justified. The high variation in the doses in this study may be due to differences in imaging protocols such as large range of mAs and scan length and also algorithms of the scanner.

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