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Evaluation of Abdomen Computed Tomography Patients' Doses in some Computed Tomography Facilities in South-South and South-East Nigeria

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Abstract: ***This study aimed at the evaluation of administered doses on patients undergoing abdomen computed tomography procedure using the 3.0 version 27/05/2015 of the impact dosimetry software. A total of six computed tomography units were visited but only three were accessed. Within the period of this study (14^{th} Aug. 2014 – 18 Sept. 2015), one hundred and seventy five adults (25 – 50 years) with body thickness (5.4 – 7.7kgm^{-1}) were investigated. 93 patients (53.1%) were males and 82 patients (46.9%) were females. The average kVp and mAs used for male and female abdomen computed tomography across the units were (kVp =120.3 and mAs =117.1) and (kVp =120.0 and mAs =116.9) respectively. The maximum average effective dose for abdomen computed tomography were obtained for male and female at computed tomography center (Y) as (male = 7.54mSv) and (female = 8.86mSv) respectively, while the minimum is at computed tomography centre (Z) as (male = 1.9mSv) and (female = 2.7mSv) respectively. The average organ doses were obtained and recorded. The results obtained were compared to other similar studies within and outside Nigeria. Some varying effects such as gender, patient's body thickness, exposure factors (kVp and mAs) and dose indicators (CTDI) were noted.***

Keywords: Abdomen, Computed Tomography, Patients, Doses, Radiation

1. Introduction

In modern medicine, the usefulness of both ionizing and non-ionizing radiation in diagnostic and therapeutic procedure is not in doubt (NNRA 2003; IAEA 2002). Ionizing radiation is of great protection concern because it can cause deterministic effect to the human body or cause a stochastic damage to the human cells. (Akinlade 2012, MC Collourgh 2012, IAEA 2007; NCRP 2004). Abdomen computed tomography procedure is of high ionizing radiation exposure (UNSCEAR 2008; NCRP 2004), so it is of great protection concern to evaluate the computed tomography doses administered to patients. This is to avoid over radiation exposure or under radiation exposure on abdomen computed tomography procedure (Sungita 2006). Previous studies have shown that radiation administered in medicine is high and might cause a risk that is too significant to ignore (NCRP 2004). Computed tomography is an x-ray procedure which is about 6% to 15% of total medical x-ray procedure (UNSCEAR 2008). From 1999 – 2006 computed tomography procedure contributed 41% to 47% total medical dose (UNSCEAR 2008, Sungita 2006; Hertz 2004). Computed tomography procedure can administer radiation doses of 50 to 500 times than other radiological procedures, which is about excess 20mSv and this is so significant to be ignored (Sungita 2006). Several reports of overexposure motivated the study of dose evaluation in abdomen computed tomography procedure (UNSCEAR 2008).

2. Literature Survey

Radiation in medicine

The use of radiation has been of great use in several areas of medicine, both in diagnostic and the therapeutic procedure (MC Collough *et al* 2012). In modern medicine radiation is used to create internal image to determine a diseased tissue (diagnostic) and treat the diseased tissue (therapeutic) (UNSCEAR 2008, NNRA 2006, IAEA 2004; NNRA 2003)

Biological effect of ionizing radiation

Broadly speaking, the negative effect of ionizing radiation is separated into two categories (deterministic effect and stochastic effect) based on level of radiation exposure and duration of exposure (IAEA 2009).

Deterministic effects occur at a high radiation exposure (above threshold dose) (MC Collough *et al* 2012)

Stochastic effects occur at low radiation exposure. It can be seen after a long period of time (MC Collough *et al* 2012, Metler 2008, IAEA 2007; Dendy and Heaton 1999)

Process of radiation interaction

There are four basic processes of interaction between x-ray and matter. These include photo-electric effect, Compton scattering, Pair production, Coherent scattering or Raleigh scattering.

Radiation dosimetry

This is a quantitative measure to determine the quantity of radiation deposited in a material or medium directly or indirectly from an ionizing radiation. There are several estimations in radiation dosimetry, such as Particle and Energy flounce, Exposure, Kerma, Absorbed dose, Equivalent dose, Effective dose, Dose limit, CTDI (Kramer 2011, Shaw and Crovail 2008, ICRU 2005, Podgorsak 2005, NNRA 2003, Yakoumakis ., 2001,Dendy and Heaton 1999; Lambadi 1999)

3. Problem Definition

Exposure of organs to ionizing radiation from abdomen computed tomography procedure may cause negative damage or long term deformation depending on the type of radiation, dose rate, region of body exposed and health of exposed person (Asgher 2008, IAEA 2007; NNRA 2006). Preliminary survey reports show that most facilities in Nigeria are old with no implementation of quality control and radiation dose monitoring for patients, personnel, and the general public. This may result in over radiation or under radiation exposure of patient.

4. Material and Methods

This study was carried out from 14th aug. 2014 to 18th sept. 2015. A total of six computed tomography units were visited (in Akwa Ibom, Rivers, Cross river and Imo state) but only three were accessed (unit X, Y and Z). 175 patients were investigated and their data recorded (male = 93 and female = 82). The type of computed tomography machines, manufacturing date, installation date and present status were recorded. The exposure factors, tube potential (kVp) and tube loading (mAs) were obtained from the machine DICOM and recorded. The organ and effective dose were evaluated by dosimetry software (impact version 3.0, 27/05/2015) which took care of

- Weighted CTDI (CTDI$_W$)
- Volume CTDI (CTDI$_V$)
- Dose length product (DLP)
- Individual organ dose (mSv)
- Effective dose (mSv)

Other parameters recorded in a – c were also taking care of

a) Dose variations for different gender
b) Dose variations in different scanner models
c) Dose variations in different age groups.

The organ and effective doses obtained from different computed tomography units were compared using a t-test (Oliveira 2011)

5. Results and Discussion

The number of patients that underwent abdomen computed tomography in the three accessed units (X, Y and Z) was distributed as shown in fig 1. The mean age of these 175 patients ranged between (25–50) 30.8years. They are all reproductive adults unlike some other previous studies which concentrated on age above 70 years (Akinlade *et al.*, 2012, Ogundare 2004). The average body thickness of the patients investigated was giving as 6.7kgm^{-1}.

The facility status, exposure factors, individual organ doses and whole body effective doses were recorded in table 1.0, 2.0 3.0 and 4.0 respectively. The equipment type of all accessed units was the same (GE).

The average kVp and mAs used during the study were (male = 120.3 and female = 120.0) and (male = 117.1 and female 116.9) respectively.

The effective dose evaluated from abdomen computed tomography in the accessed units (X, Y and Z) were as shown in fig 2. From table 4 and fig. 2, the maximum effective dose was obtained at center (Y) while the minimum effective dose was at center (Z).

A statistical tool showed ($p > 0.05$) that there was no significant difference in doses received by individual organs as well as the whole body effective doses on male and female patients.

Comparing the effective doses obtained from this study with other similar studies, the centers X and Z have effective doses lower than UK'S range. In center Y, the average effective dose is slightly higher than UK'S range (0.09 – 6.00) mSv but all doses obtained were below the IAEA recommended value (10mSv). They are all within the range of results obtained from other similar studies (1.8 – 23.4) mSv (Ogbole 2010, Olowokere 201; Osei 2006)

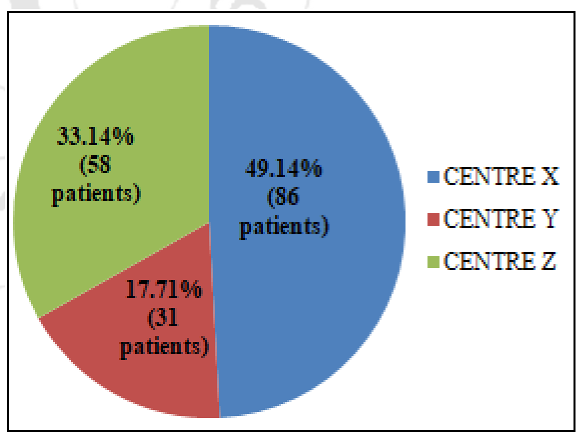

Figure 1: The patients' abdomen computed tomography population distribution

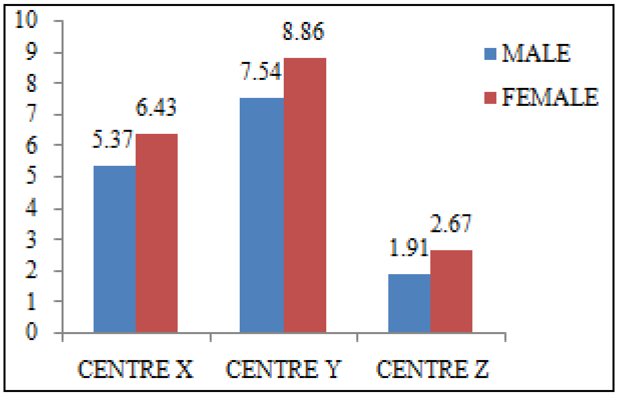

Figure 2: The effective dose evaluated from abdomen computed tomography

Table 1: Computed tomography facility record

S/A	CT centre	Machine model	Manufactured year	Installation year	CT unit status
1	U	-	-	-	Not accessed
2	V	Siemens	No record	2003	Not functional
3	W	GE	No record	No record	Not functional
4	X	GE	1997	2008	Functional
5	Y	GE	1997	2005	Functional
6	Z	GE	1997	2012	Functional

Table 2: Average exposure factors used

CT facility	Peak killovoltage (kVp)		Milliampere seconds (mAs)	
	Male	Female	Male	Female
Centre X	120.49	120.00	124.50	130.78
Centre Y	120.49	120.00	125.40	118.48
Centre Z	120.00	120.00	101.46	101.46

Table 3: Average organ doses from abdomen CT examination

Organs	Average effective dose x 10^{-3} (mSv)					
	Centre X		Centre Y		Centre Z	
	Male	Female	Male	Female	Male	Female
Gonad	0.41	1.08	1.28	1.24	0.41	0.29
b/marrow	497.66	419.55	596.90	566.20	190.00	136.50
Colon	13.55	21.99	13.58	13.38	4.17	3.00
Lung	1744.00	1801.59	2711.10	2556.00	846.70	610.00
Stomach	182.20	212.41	289.30	275.00	84.67	61.00
Bladder	0.58	0.57	0.65	0.27	0.12	0.09
Breast	1305.60	1512.95	2144.30	2154.90	1926.73	667.50
Esophagus	667.06	706.02	1087.90	1059.40	199.30	230.00
Thyroid	30.03	54.45	53.40	51.40	15.30	11.10
Skin	28.47	24.91	36.17	35.33	15.30	11.10
Bone surface	73.04	67.26	99.70	95.04	36.00	26.00

Table 4: Average whole body effective dose from abdomen CT examination from different CT units (mSv)

Centre X		Centre Y		Centre Z	
Male	Female	Male	Female	Male	Female
5.37	6.43	7.54	8.86	2.67	1.91

6. Conclusion

In this study, doses obtained were in line with IAEA recommended value so it could be said that, doses delivered are appropriate for the patients, personnel and entire public. It is also observed that impact dosimetry software is appropriate for the evaluation of patient doses (organ and effective doses). There were variation in exposure factors (kVp and mAs) and dose calculated but they were not above CEC recorded value. They were also in line with results of other similar studies in Nigeria.

7. Future Scope

For a good abdomen computed tomography procedure, the computed tomography exposure factors should be selected with safety of the patients, personnel and the general public in mind. In other words the choice of selection is done so that the computed tomography machine can release radiation doses as low as reasonable achievable (ALARA) without affecting the diagnostic information required on the image.

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