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Evaluation of Patients Doses During 2 and 16 Slice CT Scan Procedure in Adults

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Authors' contributions

The study was carried out in collaboration among all authors. All authors were involved in the design, literature reviews, data collection, and analyses of the study. The study was read and approved by all the authors.

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ABSTRACT

Aim: Computed tomography (CT) is an innovation that has contributed immensely to modern medicine. CT uses ionising radiation in the form of x-rays which has become a source of concern. The study is to evaluate patients' doses during 2 and 16 slices CT scan procedure in adults.
Study Design: The study was an empirical study.
Place and Duration of Study: It was carried out with 50 patients referred for brain CT in two separate radiology facilities having 2 and 16 slices CT scans in Port Harcourt over 6months duration.
Methodology: The examination was done in accordance with standard protocols for brain CT. Radiation dose was measured with a coded themoluminiscent dosimeter (TLD) chip, placed on the glabella and held in position with a transparent adhesive tape before the exposures and removed

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immediately after the investigation, labeled and sent to the Radiation Dosimetric Laboratory of the Regional Centre for Energy Research and Training (CERT), Zaria for reading. The effective dose was obtained from the absorbed dose by multiplying the absorbed dose with tissue weighting factor of 0.01 for the brain. The cancer and hereditary effects per investigation were obtained by using the cancer risk coefficients (F_{CR} = 5.5X10^{-2} Sv^{-1}) and hereditary risk coefficients (F_{GE} = 0.2X10^{-2} Sv^{-1}) obtained from ICRP 103 publication. All variables collated were tabulated into a data sheet and analyzed using Statistical Package for Social Sciences (SPSS) windows version 22.30 statistical software (SPSS Inc, Chicago, Illionois, USA). The results were presented on tables, charts and graphs. A descriptive statistical tool was used to - determine central tendencies while Pearson correlation and linear regression analysis model was used to evaluate correlation between variables.

Results: The mean absorbed dose (±SD) was 51.37(±8.07)mSv and 89.97±13.25mSv during 2 and 16 slices CT procedures respectively. The Lifetime Attributable Risk is approximately 3 and 5 per 10^5 CT procedures during 2 and 16 slice CT procedures while the Hereditary Risks was 1 and 2 per 10^6 CT procedures for 2 and 16 slice CT procedures respectively. There was a weak correlation between BMI and cancer risk with a Pearson Correlation coefficient (r) of 0.130 but no association between cancer risk and age during 2 slice CT scanner.

Conclusion: Absorbed dose increases with increase on the CT slices, likewise cancer and hereditary risk increases with increase in CT slices. Thus, notwithstanding how low a radiation exposure could be it can still necessitate malignant risk.

Keywords: Computed tomography; radiation dose; effective dose; ionizing radiation; cancer risk; hereditary risk; lifetime attributable risk; thermoluminescent dosimeter.

1. INTRODUCTION

Computed tomography (CT) is a significant scientific innovation that has contributed immensely to modern medical practice [1,2]. CT scan has improved medical imaging in the diagnosis and treatment of patients thereby improving the healthcare delivery system [3,4]. Generally, because of the increasing relevance of CT scan, its use has rapidly increased both in the United States of America and globally especially in the past 10 years [5]. Following the invention of CT in 1971, brain CT scan has improved the diagnostic yield of neurological disorders in the past 50 years [6]. It shows the internal structures of the body and lesions based on their attenuation which is a function of the physical densities, quantity and quality of the radiation and the sectional thickness of the slices.

This imaging modality uses ionising radiation in the form of x-rays which are produced when high energy fast moving electrons strike a tungsten target [4,7]. The emitted x-rays have the potential to penetrate the body, interact with the internal structures and produce cross-sectional images for improved diagnostic yield [8]. The produced images are consequent upon the quantity of radiation and the attenuation capabilities of the tissue [7].

The medical benefit of CT, has significantly contributed to the increasing frequency in the use of the imaging modality [9] but, notwithstanding its benefits the risk associated with its use has also become a concern to many [10]. Because every CT scan delivers some amount of radiation dose to the body that is potentially carcinogenic [11].

The medical use of ionising radiation has become one of the major sources of exposure to ionizing radiation among humans according to the United Nations environment Annual Report [12]. The United Nation Scientific Committee on Effect of Atomic Radiation reported that on average for countries in Health-care level I, CT represents 6% of all diagnostic medical x-ray examinations and accounts for 41% of the total population radiation dose [13,14].

These concerns are associated with cancer risk which is associated with the use of high radiation doses as used in CT [15]. No doubt diagnostic radiology has been revolutionized by Computed tomography (CT) and its usage has been increasing as the day goes by [16]. The increasing usage can be attribute to its brilliant sectional contrast and aid to patient management.

The anticipated cancer risk from exposure to ionizing radiation could be extrapolated from survivors of nuclear attack [16,17]. Because of the medical benefit of CT, there is an increasing frequency in the use of the modality especially for brain lesions to diagnose, intra-axial haemorrhages. Space occupying brain masses, cerebral infracts as well as other lesions [17]. There is paucity of data concerning radiation risk to patients during brain computed tomography investigation in our environment using different CT machine slices. Therefore, the study is aimed to evaluate patients' doses during 2 and 16 slices CT scan procedure in adults.

2. MATERIALS AND METHODS

The study was an empirical study with patients referred for brain CT scan examination. A sample size was fifty (50) being patients referred for brain CT examination from January to June 2021 that voluntarily accepted to participate. The study was carried out in two separate radiology facilities having 2 and 16 slice computed tomography scans in Port Harcourt. The 2 Slice Toshiba CT Machine was manufactured in USA in 2000 while the second machine was a 16 Slice Philips CT Machine (manufactured in Germany in 2004). The two machines have recent calibrations with regular quality control measurements. The operating parameters of the machines are all within acceptable limits. A thermoluminescent dosimeter was used to measure the amount of radiation to the brain which was read using Harshaw TLD Model 4500 Reader.

The procedure was explained to the participants in detail, followed by obtaining informed consent. The participants were requested to change and wear a gown and then the age, height and weight of the patients were recorded for each investigation. The examination was done with the patient lying supine on the CT gantry table in accordance with standard protocols for brain CT with the external auditory meatus (EAM) is at the center of the gantry.

Radiation dose to the brain was measured with a coded thermoluminiscent dosimeter (TLD) chips (TLD LiF-100) which was placed on the glabella been the centering point and held in position with a transparent (radiolucent) adhesive tape before the exposures. After the completion of the examination, the TLD was immediately removed and labeled appropriately against the patient's name. The TLDs were then sent to the Radiation Dosimetric Laboratory of the Regional Centre for Energy Research and Training (CERT), Zaria for reading and annealing. The reading was done using Harshaw 4500 dual channel TLD reader.

2.1 Patients Radiation Dose

The Radiation dose to the brain was the measured values from the coded thermoluminescent dosimeter (TLD) chips (TLD LiF-100) that were read with Harshaw 4500 dual TLD reader at the Radiation Dosimetric Laboratory of the Regional Centre for Energy Research and Training (CERT), Zaria.

2.2 Effective Dose

The effective dose was obtained from the absorbed dose by using equation 1 as show below. A tissue weighting factor of 0.01 for the brain was used to convert the absorbed dose to effective dose in Sievert (Sv) as recommended by the International Commission on Radiological Protection (ICRP 103).

$$\mathrm{E} = \mathrm{HTw_T} \tag{1}$$

2.3 Radiation Cancer Risk of 2 and 16 Slice CT Scanners

The Cancer risk was estimated for each procedure. The cancer risk (R_{CR}) per investigation was obtained by multiplying the effective dose (E_{eff}) with the risk coefficients (F_{CR}) F_{CR} = 5.5X10^{-2} Sv^{-1} obtained from ICRP 103 (ICRP, 2007) using equation 2.

$$R_{CR} = F_{CR}\ x\ E_{eff} \tag{2}$$

2.4 Heredity Risks Evaluation of 2 and 16 Slice CT Scanners

The radiation risk of genetic effects (R_{GE}) was obtained by multiplying the effective dose by the hereditary risk factor coefficients F_{GE} = 0.2X10^{-2} Sv^{-1} which is obtained from ICRP 103 publication (ICRP, 2007) using equation 3.

$$R_{GR} = F_{GE}\ x\ E_{eff} \tag{3}$$

2.5 Method of Data Analysis

All other variables obtained from the study were collated, documented into tabulated data sheet and then analyzed using Statistical Package for Social Sciences (SPSS) windows version 22.30 statistical software (SPSS Inc, Chicago, Illionois , USA). The results obtained will be presented in tables, charts and graphs using Microsoft excel package.

A descriptive statistical tool was used to determine central tendencies and Pearson correlation coefficient and linear regression analysis model will also be used to evaluate correlation between variables.

3. RESULTS

The absorbed doses of patients during 2 and 16 slices CT scanner procedures are enumerated in Tables 1 and 2 respectively. According to Table 1 patient absorbed radiation dose (in mSv) ranges from 38.00mSv to 68.00mSv with a mean patient absorbed radiation dose (±standard deviation) of 51.37(±8.07) mSv during 2 slices CT scanner procedure. Table 2 enumerates the patient absorbed radiation dose (mSv) during a 16 slice CT scanner procedure which ranged from 68.50mSv to 142.00mSv with a mean patient absorbed radiation dose (±standard deviation) of 89.97±13.25mSv.

The associated estimated risk using 2 slice CT scanner shows that the cancer risk ranged from 2.09×10^{-5} to 3.74×10^{-5} with a maximum cancer risk of approximately 4 persons per 10,000 people (3.74×10^{-5}) as shown on Tables 1 and 3. According to Tables 2 and 3, the maximum cancer risk using 16 slices CT was approximately 8 persons per 100,000 people (7.8100×10^{-5}). The mean cancer risk in during 2 slice CT scanner procedure is 2.83×10^{-5}(±0.4437) whereas that with 16 slices CT scanner procedure was 4.95×10^{-5}(±0.73×10^{-5}) respectively (Tables 1, 2 and 3).

Table 4 shows the gender distribution of patient radiation dose among males and females during 2 slice CT scanner procedure. As illustrated on Table 4, the mean absorbed radiation dose among the females (51.65±6.60mSv) was higher than that received among the males (51.16±9.30mSv). Conversely, during a 16 slice CT scanner procedure the mean absorbed radiation dose received by female (85.48±7.50mSv) was lesser than that of the male (94.12±16.15mSv) as shown on Table 5.

Table 1. Radiation dose to the patients using 2 slice CT scanner

S/N	Chip ID	Patients Sample	Age (year)	BMI	Patient Radiation Dose (mSv)	Effective Dose (mSv)	C.Risk $\times 10^{-5}$	H.RISK $\times 10^{-6}$
1.	A1	P1	39.00	24.20	48.20	0.48	2.64	0.96
2.	A2	P2	49.00	22.20	55.40	0.55	3.03	1.10
3.	A3	P3	54.00	30.12	68.00	0.68	3.74	1.36
4.	A4	P4	54.00	24.10	53.00	0.53	2.92	1.06
5.	A5	P5	48.00	23.90	42.00	0.42	2.31	0.84
6.	A6	P6	56.00	24.60	49.00	0.49	2.70	0.98
7.	A7	P7	57.00	23.40	67.00	0.67	3.69	1.34
8.	A8	P8	57.00	27.40	38.20	0.38	2.09	0.76
9.	A9	P9	67.00	24.78	43.00	0.43	2.37	0.86
10.	A10	P10	58.00	24.98	38.20	0.38	2.09	0.76
11.	A11	P11	58.00	33.80	57.00	0.57	3.14	1.14
12.	A12	P12	49.00	26.44	58.00	0.58	3.19	1.16
13.	A13	P13	67.00	27.68	38.00	0.38	2.09	0.76
14.	A14	P14	63.00	22.79	47.00	0.47	2.59	0.94
15.	A15	P15	65.00	28.34	46.60	0.47	2.59	0.94
16.	A16	P16	65.00	23.00	56.00	0.56	3.08	1.12
17.	A17	P17	66.00	29.38	55.00	0.55	3.03	1.10
18.	A18	P18	66.00	25.93	54.00	0.54	2.97	1.08
19.	A19	P19	67.00	25.10	44.50	0.45	2.48	0.90
20.	A20	P20	68.00	24.10	57.00	0.57	3.14	1.14
21.	A21	P21	67.00	25.50	56.00	0.56	3.08	1.12
22.	A22	P22	67.00	24.30	48.20	0.48	2.64	0.96
23.	A23	P23	70.00	25.10	53.00	0.53	2.92	1.06
24.	A24	P24	72.00	34.10	54.00	0.54	2.97	1.08
25.	A25	P25	74.00	24.30	58.00	0.58	3.19	1.16

C.Risk: Cancer risk; H.RISK: Hereditary risk

Table 2. Radiation dose to the patients using 16 slice CT scanner

S/N	Chip ID	Patients Sample	Age (year)	BMI	Patient Radiation Dose (mSv)	Effective Dose (mSv)	C.Risk $\times 10^{-5}$	H. RISK $\times 10^{-6}$
1.	B1	P1	42.00	27.60	88.00	0.88	4.84	1.76
2.	B2	P2	53.00	20.90	94.00	0.94	5.17	1.88
3.	B3	P3	44.00	32.60	97.00	0.97	5.34	1.94
4.	B4	P4	54.00	20.40	101.40	1.01	5.56	2.02
5.	B5	P5	45.00	20.30	142.00	1.42	7.81	2.84
6.	B6	P6	56.00	22.70	98.00	0.98	5.39	1.96
7.	B7	P7	66.00	20.45	76.00	0.76	4.18	1.52
8.	B8	P8	58.00	26.28	86.80	0.87	4.79	1.74
9.	B9	P9	57.00	24.50	86.40	0.86	4.73	1.72
10.	B10	P10	59.00	22.50	86.80	0.87	4.79	1.74
11.	B11	P11	58.00	33.80	98.00	0.98	5.39	1.96
12.	B12	P12	39.00	38.50	88.60	0.89	4.90	1.78
13.	B13	P13	61.00	27.68	80.60	0.81	4.46	1.62
14.	B14	P14	53.00	22.79	85.40	0.85	4.68	1.70
15.	B15	P15	55.00	28.34	92.20	0.92	5.06	1.84
16.	B16	P16	65.00	22.64	96.60	0.97	5.34	1.94
17.	B17	P17	66.00	29.38	68.50	0.69	3.80	1.38
18.	B18	P18	66.00	25.93	84.00	0.84	4.62	1.68
19.	B19	P19	67.00	25.10	76.00	0.76	4.18	1.52
20.	B20	P20	67.00	20.37	87.40	0.87	4.79	1.74
21.	B21	P21	67.00	28.71	85.60	0.86	4.73	1.72
22.	B22	P22	67.00	21.80	85.00	0.85	4.68	1.70
23.	B23	P23	70.00	25.76	93.00	0.93	5.12	1.86
24.	B24	P24	72.00	34.08	84.00	0.84	4.62	1.68
25.	B25	P25	75.00	21.80	88.00	0.88	4.84	1.76

C.Risk (Cancer Risk) ; H.Risk (hereditary Risk)

Table 3. Cancer and Hereditary risk of the facilities

FACILITY		CANCER RISK $\times 10^{-5}$	Hereditary Risk $\times 10^{-6}$
FACILITY A	Mean	2.825	1.027
(2 SLICE	Minimum	2.090	0.760
MACHINE)	Maximum	3.740	1.360
FACILITY B	Mean	4.950	1.800
(16 SLICE	Minimum	3.795	1.380
MACHINE	Maximum	7.810^5	2.840

Comparison of the mean effective dose of the index study with other studies according to ICDR 103 recommendations show that in result from the index study was lower than that of Netherland (1.5mSv) and Mkimel et al. [18] (0.65mSv) (Table 6).

Among the male participates that underwent 2 slice the mean absorbed radiation dose was 51.16±9.304 with a mean effective dose of 0.512±0.093 (Table 7). Meanwhile the mean effective dose among the female participates was 0.5165+0 .06596 which was slightly higher than that received by the male (Tables 7 and 8).

With 16 slices CT the mean effective dose of the male and females was of 0.941±0.162 and 0.855±0.075 respectively (Tables 9 and 10).

Table 11 shows the correlation among radiation doses, patient's age, BMI and Cancer Risk of participants during 2 slice CT scanner procedure which revealed a weak Pearson correlation between BMI and cancer risk with a Pearson Correlation coefficient (r) of 0.130 and no correlation between cancer risk and age.

The correlation among radiation doses, patient's age, BMI and Cancer Risk of participants during

16 slice CT scanner procedure which revealed a negative weak Pearson correlation between age and cancer risk with a Pearson Correlation coefficient (r) of -0.460 (Table 12). The correlation among radiation dose, patients age, BMI and hereditary risk of patients in during 2 and 16 slice CT scan procedures show similar findings as with cancer risk as shown on Tables 13 1nd 14 respectively.

Table 4. Gender distributions of absorbed doses of patients from TLD reading during 2 slice CT scanner procedure

	FEMALE			MALE		
S/No	**Age (year)**	**BMI**	**Radiation Dose (mSv)**	**Age (year)**	**BMI**	**Radiation Dose (mSv)**
1	58	33.8	57.0	39	24.2	48.2
2	49	26.44	58.0	49	22.2	55.4
3	67	27.68	38.0	54	30.12	68.0
4	63	22.79	47.0	54	24.1	53.0
5	65	28.34	46.6	48	23.9	42.0
6	65	23	56.0	56	24.6	49.0
7	66	29.38	55.0	57	23.4	67.0
8	66	25.93	54.0	57	27.4	38.2
9	67	25.1	44.5	67	24.78	43.0
10	72	34.1	54.0	58	24.98	38.2
11	74	24.3	58.0	68	24.1	57.0
12	-	-	-	12	67	25.5
13	-	-	-	13	67	24.3
14	-	-	-	14	70	25.1

Table 5. Gender distributions of absorbed doses of patients from TLD reading during 16 slice CT scanner procedure

	MALE			FEMALE		
S/No	**Age (year)**	**BMI**	**Radiation Dose (mSv)**	**Age (year)**	**BMI**	**Radiation Dose (mSv)**
1	42	27.6	88.0	53	22.79	85.4
2	53	20.9	94.0	55	28.34	92.2
3	44	32.6	97.0	65	22.64	96.6
4	54	20.4	101.4	66	29.38	68.5
5	45	20.3	142.0	66	25.93	84.0
6	56	22.7	98.0	67	25.1	76.0
7	66	20.45	76.0	67	20.37	87.4
8	58	26.28	86.8	67	28.71	85.6
9	57	24.5	86.4	67	21.8	85.0
10	59	22.5	86.8	70	25.76	93.0
11	58	33.8	98.0	72	34.08	84.0
12	39	38.5	88.6	75	21.8	88.0
13	61	27.68	80.6	-	-	-

Table 6. Comparison of Effective dose with other studies according to ICDR 103 recommendations

STUDY	Obtained value
Netherland (2013)	1.5
NSRD (2010)	1.5
HPA	1.4
Mkimel *et al*., 2019	0.65
FACILITY A	0.51
FACILITY B	0.90

Table 7. Males Gender distribution of absorbed doses of patients from TLD reading with associated cancer risk during 2 slice CT scanner procedure

S/No	Age (year)	BMI	Radiation Dose (mSv)	Effective Dose (mSv)	C.Risk $\times 10^{-5}$	H.Risk $\times 10^{-6}$
1	39	24.2	48.2	0.48	2.65	0.96
2	49	22.2	55.4	0.55	3.05	1.11
3	54	30.12	68	0.68	3.74	1.36
4	54	24.1	53	0.53	2.92	1.06
5	48	23.9	42	0.42	2.31	0.84
6	56	24.6	49	0.49	2.70	0.98
7	57	23.4	67	0.67	3.69	1.34
8	57	27.4	38.2	0.38	2.10	0.76
9	67	24.78	43	0.43	2.37	0.86
10	58	24.98	38.2	0.38	2.10	0.76
11	68	24.1	57	0.57	3.14	1.14
12	67	25.5	56	0.56	3.08	1.12
13	67	24.3	48.2	0.48	2.65	0.96
14	70	25.1	53	0.53	2.92	1.06

C.Risk (Cancer Risk) ; H.Risk (hereditary Risk)

Table 8. Females Gender distribution of absorbed doses of patients from TLD reading with associated cancer and hereditary risk during 2 slice CT scanner procedure

S/No	Age (year)	BMI	Effective Dose (mSv)	C.Risk $\times 10^{-5}$	H.Risk $\times 10^{-6}$
1	58	33.8	0.57	3.14	1.14
2	49	26.44	0.58	3.19	1.16
3	67	27.68	0.38	2.09	0.76
4	63	22.79	0.47	2.59	0.94
5	65	28.34	0.47	2.59	0.94
6	65	23	0.56	3.08	1.12
7	66	29.38	0.55	3.03	1.10
8	66	25.93	0.54	2.97	1.08
9	67	25.1	0.45	2.48	0.90
10	72	34.1	0.54	2.97	1.08
11	74	24.3	0.58	3.19	1.16

C.Risk (Cancer Risk) ; H.Risk (hereditary Risk)

Table 9. Males gender distribution of absorbed doses of patients from TLD reading with associated cancer and hereditary risk during 16 slice CT scanner procedure

S/No	Age (year)	BMI	Effective Dose (mSv)	C.Risk $\times 10^{-5}$	H.Risk $\times 10^{-6}$
1	42	27.6	0.88	4.84	1.76
2	53	20.9	0.94	5.17	1.88
3	44	32.6	0.97	5.34	1.94
4	54	20.4	1.014	5.58	2.03
5	45	20.3	1.42	7.81	2.84
6	56	22.7	0.98	5.39	1.96
7	66	20.45	0.76	4.18	1.52
8	58	26.28	0.868	4.77	1.74
9	57	24.5	0.864	4.75	1.73
10	59	22.5	0.868	4.77	1.74
11	58	33.8	0.98	5.39	1.96
12	39	38.5	0.886	4.87	1.77
13	61	27.68	0.806	4.43	1.61

C.Risk (Cancer Risk) ; H.Risk (hereditary Risk)

Table 10. Female gender distributions of absorbed doses of patients from TLD reading with associated cancer and hereditary risk 16 slice CT scanner procedure

S/No	Age(year)	BMI	Effective Dose (mSv)	C.Risk $\times 10^{-5}$	H.Risk $\times 10^{-6}$
1	53	22.79	0.854	4.70	1.71
2	55	28.34	0.922	5.07	1.84
3	65	22.64	0.966	5.31	1.93
4	66	29.38	0.685	3.77	1.37
5	66	25.93	0.84	4.62	1.68
6	67	25.1	0.76	4.18	1.52
7	67	20.37	0.874	4.81	1.75
8	67	28.71	0.856	4.71	1.71
9	67	21.8	0.85	4.68	1.7E
10	70	25.76	0.93	5.12	1.86
11	72	34.08	0.84	4.62	1.68
12	75	21.8	0.88	4.84	1.76

C.Risk (Cancer Risk) ; H.Risk (hereditary Risk)

Table 11. Correlation between radiation dose with age, BMI and Cancer Risk of participants facility A

		AGE	BMI	Absorbed Dose	CANCERRISK
AGE	Pearson Correlation	1	.186	-.007	.002
	Sig. (2-tailed)		.373	.975	.994
BMI	Pearson Correlation	.186	1	.126	.130
	Sig. (2-tailed)	.373r		.549	.535
Absorbed Dose	Pearson Correlation	-.007	.126	1	1.000**
	Sig. (2-tailed)	.975	.549		.000
CANCERRISK	Pearson Correlation	.002	.130	1.000**	1
	Sig. (2-tailed)	.994	.535	.000	

***. Correlation is significant at the 0.01 level (2-tailed).*. Correlation is significant at the 0.05 level (2-tailed)*

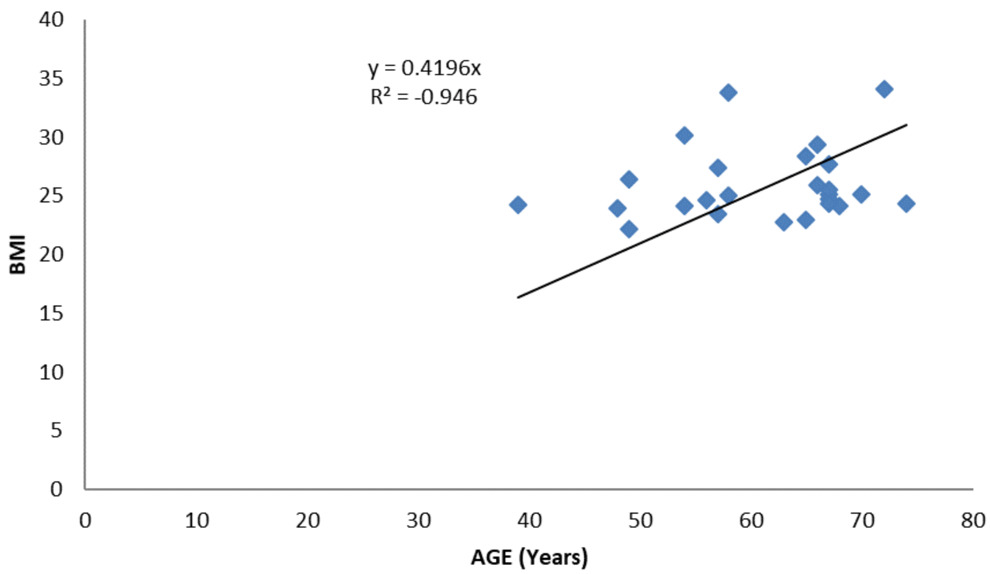

Fig. 1. Scatter Plot of Patients age With BMI during 2 slice CT scan procedure

Table 12. Correlation between radiation dose with age, BMI, and Cancer risk of participants in FACILITY B

		AGE	BMI	Absorbed Dose	CANCERRISK
AGE	Pearson Correlation	1	-.247	-.460*	-.460*
	Sig. (2-tailed)		.234	.021	.021
BMI	Pearson Correlation	-.247	1	-.203	-.196
	Sig. (2-tailed)	.234		.330	.347
Absorbed Dose	Pearson Correlation	-.460*	-.203	1	1.000**
	Sig. (2-tailed)	.021	.330		.000
CANCERRISK	Pearson Correlation	-.460*	-.196	1.000**	1
	Sig. (2-tailed)	.021	.347	.000	

***. Correlation is significant at the 0.01 level (2-tailed).*. Correlation is significant at the 0.05 level (2-tailed)*

Table 13. Correlation among radiation dose with age, BMI and hereditary risk of participants facility A

		AGE	BMI	Absorbed Dose	H.DRISK
AGE	Pearson Correlation	1	.186	-.007	.002
	Sig. (2-tailed)		.373	.975	.994
BMI	Pearson Correlation	.186	1	.126	.130
	Sig. (2-tailed)	.373		.549	.535
Absorbed Dose	Pearson Correlation	-.007	.126	1	1.000**
	Sig. (2-tailed)	.975	.549		.000
HERIDRISK	Pearson Correlation	.002	.130	1.000**	1
	Sig. (2-tailed)	.994	.535	.000	

***. Correlation is significant at the 0.01 level (2-tailed).*. Correlation is significant at the 0.05 level (2-tailed)*

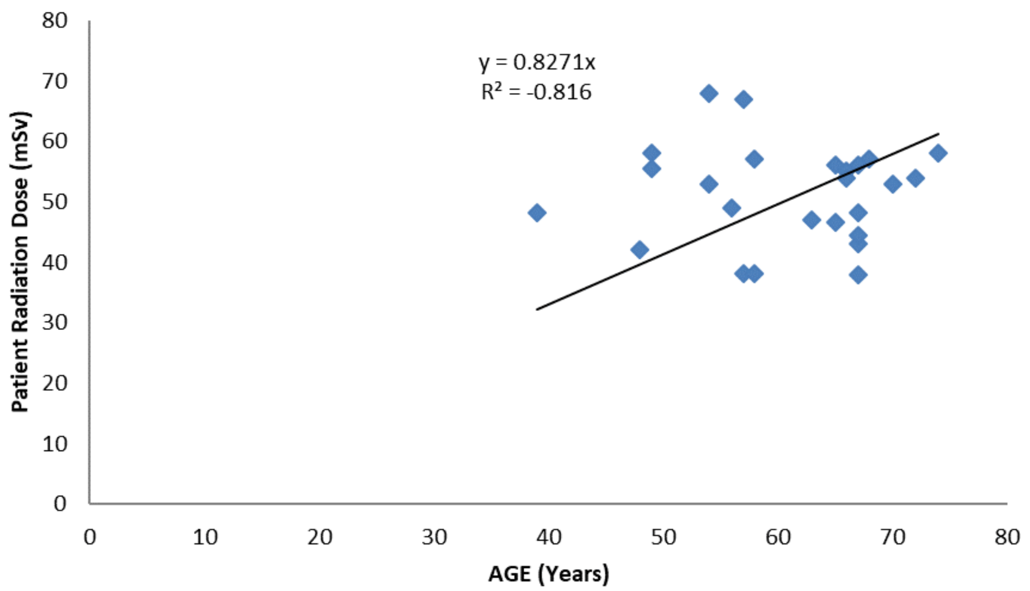

Fig. 2. Correlation of patients absorbed radiation dose with age during 2 slice CT scan procedure

Table 14. Correlation among radiation dose with age, BMI, and Hereditary Risk of participants facility B

		AGE	BMI	Absorbed Dose	H.DRISK
AGE	Pearson Correlation	1	-.247	-.460*	-.460*
	Sig. (2-tailed)		.234	.021	.021
BMI	Pearson Correlation	-.247	1	-.203	-.196
	Sig. (2-tailed)	.234		.330	.347
Absorbed Dose	Pearson Correlation	-.460*	-.203	1	1.000**
	Sig. (2-tailed)	.021	.330		.000
HERIDRISK	Pearson Correlation	-.460*	-.196	1.000**	1
	Sig. (2-tailed)	.021	.347	.000	

***. Correlation is significant at the 0.01 level (2-tailed)., *. Correlation is significant at the 0.05 level (2-tailed)*

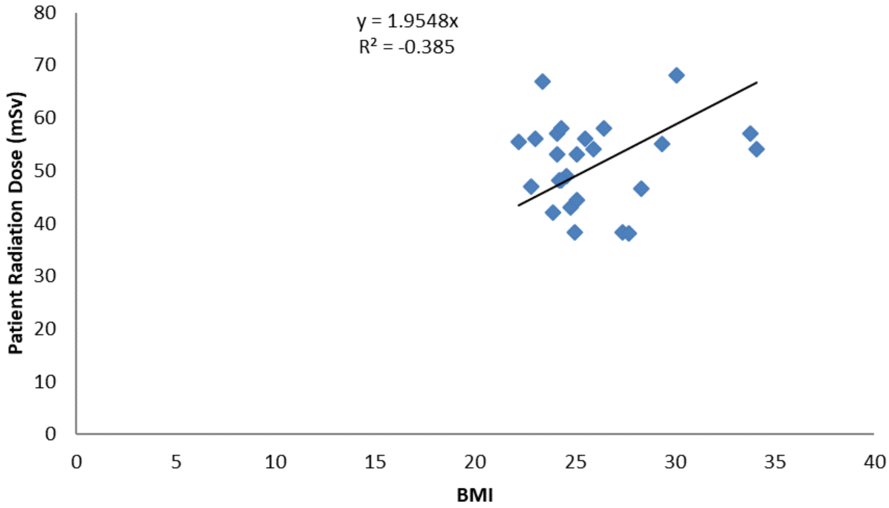

Fig. 3. Scatter plot of patients absorbed radiation dose with BMI during 2 slice CT scan procedure

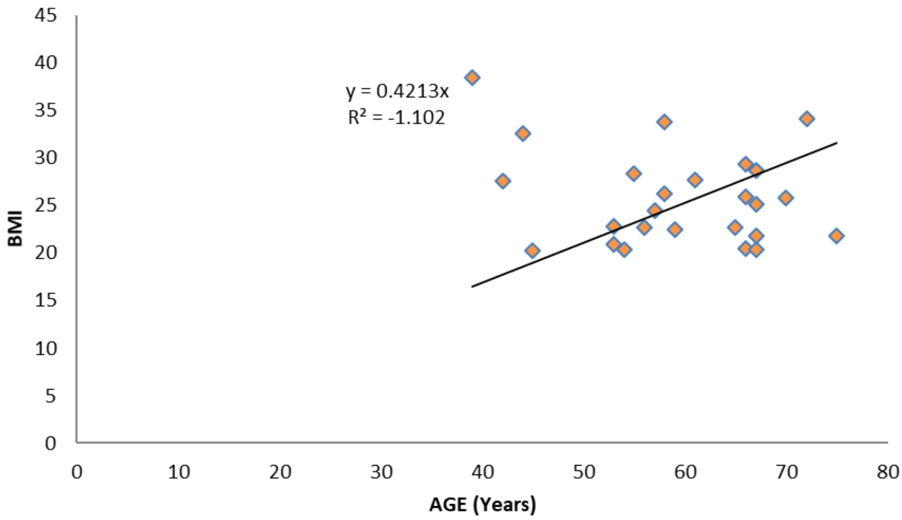

Fig. 4. Scatter Plot of Patients age With BMI during 16 slice CT scan procedure

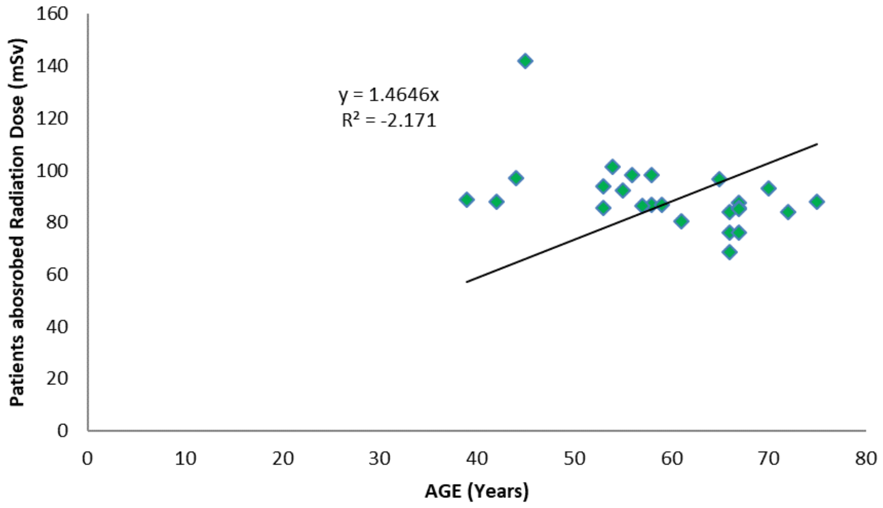

Fig. 5. scatter plot of patients absorbed radiation dose with age during 16 slice CT scan procedure

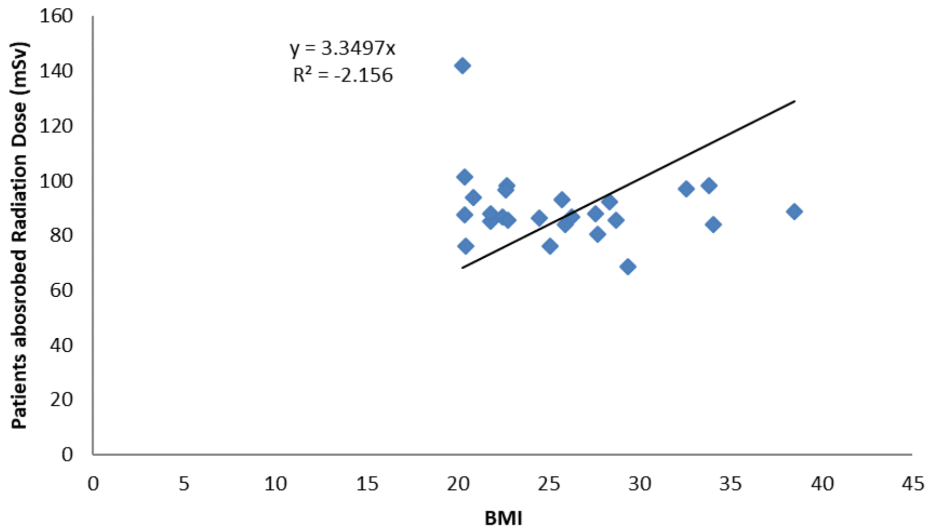

Fig. 6. Scatter plot of patients absorbed radiation dose with BMI during 16 slice CT scan procedure

Fig. 1 show Scatter Plot of Patients age With BMI in 2 slice CT scan. The scatter plot revelled a patterned distribution of variables which signifies a linear relationship between Patients age With BMI (Fig. 1). Linear regression analysis of the plot yielded a linear equation (equation 1) where y is patient BMI and x is age (in years) (Fig. 4).

$$y= 0.4196x \qquad (r^2= -0.946) \qquad (4)$$

The relationship between patients absorbed radiation dose and age using 2 slice CT procedure is shown on Fig. 2. The scatter plot shows a non-patterned distribution of variables which signifies non-linear relationship between the absorbed dose and age (Fig. 2). Linear regression analysis of the plot yielded a linear equation (equation 5).

$$y= 0.8271x \qquad (r^2= -0.816) \qquad (5)$$

The relationship of patients absorbed radiation dose with BMI using 2 slice CT scan was illustrated on Fig. 3. The scatter plot of patient absorbed radiation dose against BMI in facility A also shows a non-patterned distribution of variable which signifies non-linear relationship between the patients absorbed radiation dose and BMI (Fig. 3). Linear regression analysis yielded a linear equation (equation 6).

$$y= 1.9546x \qquad (r^2= -0.385) \qquad (6)$$

Fig. 4 show Scatter Plot of Patients age With BMI in 16 slice CT scan. The scatter plot revelled a fairly patterned distribution of variables which signifies a linear relationship between Patients age With BMI (Fig. 4). Linear regression analysis of the plot yielded a linear equation (equation 7).

$$y= 0.4213x \qquad (r^2= -1.102) \qquad (7)$$

Fig. 5 shows a patterned distribution of variables which is suggestive of a linear relationship between the absorbed dose and age with a resultant linear equation (equation 8) where y is patient absorbed radiation dose (in mSv) and x is age (in years).

$$y= 1.4646x \qquad (r^2= -2.171) \qquad (8)$$

In Fig. 6 the relationship between the patients absorbed dose and BMI is shown with a linear regression analysis yielding equation 9.

$$y= 3.3497x \qquad r^2= -2.156; \qquad (9)$$

In equations 2, 3, 5 and 6 'y' represent the patient absorbed radiation dose (in mSv) while in equations 2, 4 and 5 'x' represents the patients age (in years). In equations 3 and 6 'x' represent the patient BMI while in equation 4 'y' represents BMI.

4. DISCUSSION

Computed tomography has contributed immensely to modern medicine, however the use of the imaging modality has become a concern to many clinician because of the use of ionizing radiation. Thus the study evaluated patients' doses during and the associated cancer and hereditary risk during 2 and 16 slices CT scan procedure in adults. Following the result we provide discussion of the associated risk that may arise from the exposure to ionizing radiation even when the dose is low.

In a study conducted to evaluate the computed tomography of the head and the risk of brain tumours during childhood and adolescence: results from a case–control study in Japan by Kojimahara et al. [19] showed a mean estimated brain dose of 32±13mGy (which is equivalent to 32±13mSv). The value obtained from the study by Kojimahara et al. [19] with TOSHIBA Aquillion 16 was lower than the value obtained in the index study for a similar machine of the same slice. The variation may be attributed to the study population wherein population of study could influence the outcome of the study [20].

In a prospective, cross-sectional study involving 30 patients aged 4months to 72years to evaluate patients absorbed radiation dose in Nigeria [18] showed an absorbed radiation dose ranged from 0.03mSv to 5.20mSv. Their study [18] used a well calibrated 32-slice Toshiba CT scanner machine which has a higher CT slice number when compared to 16 slices CT scanner. Irrespective of the scanner machine specification used in the study [18], the radiation dose was lower than that obtained in either 2 or 16 slice CT scanners. The lower absorbed radiation dose recoded in their study [1] may be due to the exposure factors used because of the inclusion of children in their study where lower exposure factors are advocated due to the increased radiosensitivity of the children, whereas, in the index study only adult population participated in the study.

The amount of radiation dose absorbed with the TLD reading in 16 slice CT scanner was higher than that of 2 slice CT scanner. This finding depicts that patients absorbed radiation dose increases with increase on the CT scan slices. In the study 'Assessment of the Radiation Dose during 16 Slices CT Examinations' by Mkimel et al. [18] documented an effective dose of 0.71mSv and 0.76mSv for males and females respectively during a head CT scan. The values in the index study were 0.94+0.16mSv (male) and 0.86+0.075mSv (female) which were higher than the values obtained in the study [18]. This can also be explained with the sample population and the use of phantoms which was employed in their study [18]. The male to female discrepancy may be due to BMI, and age which needs further evaluation with a higher sample population to clarity. Thus, it can be deduced and stated hypothetically from the findings of the index study that the effective dose increases as the number of CT scanner slices increase.

In facility A the analysis revealed that there was a weak positive correlation between age and BMI but there is no correlation between age and cancer risk. This was in keeping with the study by de Basea et al. [21] where the lifetime attributable cancer risks did not reveal a consistent dependence on age at exposure, showing different risk patterns among the exposure age groups.

The analysis also showered that there is a positive correlation between BMI and cancer risk with a Pearson's correlation coefficient (r) of 0.130. In facility B, there was no correlation between age and cancer risk and BMI.

The Lifetime Attributable cancer Risk were approximately 3 and 5 per 100,000 CT during 2 and 16 slices CT scanner scan procedures respectively. Conversely in a similar study by Semghoul et al. [22] in Morocco documented the participant cancer risk per CT procedure to be 4 and 8 per 100,000 CT scan procedures for 2 slices and 16 slices CT scanners respectively. The cancer risk from their study [22] was higher than that documented in the index study. The reason for the variance may be due to the radiation exposure factors used for the study as the higher the radiation dose the higher the cancer risk. The reason may also be attributed to geography differences, and the availability of diagnostic reference range for that population. Thirdly the sample population may have contributed to the variation observed as the sample population in the index study was higher than the number of patients that participated in their study [22].

A study to evaluate the Lifetime attributable cancer risk related to prevalent CT scan procedures in pediatric medical imaging centers [23] showed a LAR following a chest CT scan of 68.23 per 100,000 FOR patients Of <1-year-old and abdomen-pelvic CT scans of 57.30 per 100,000 for patients within the age group 10- to 15-years. The values obtained from their study [23] were higher than that obtained from the study by Semghoul et al. [22], Kadowak et al. [24] and the index study. Although the model and number of CT scanner slices used in their study [23] could not be ascertain, the fact that the study population was only children (pediatric) could have contributed to the variations observed [25,26,27].

The results from this study have shown some scientific background to the fact that CT procedures carry some risk, notwithstanding the amount of radiation used. However father multicentre study is anticipated to establish this fact and to provide more insight to the risk benefit balance of the use of CT in clinical practise.

5. CONCLUSION

Gender distribution of participants showed male predominance over females. This hypothetically opines that males have signs and symptoms or diseases requiring the need for brain CT scan investigation than females. Absorbed radiation dose to the brain increases with increase on the CT slices, this was evident by the fact that the amount of radiation dose absorbed in 16 slice CT scanner procedure was higher than that of 2 slice CT scanner procedure. According to the study, the absorbed radiation dose among the females was higher than that received among the males which may be attributed to the BMI of the participants which has the same gender distribution as that of the absorbed dose.

The lifetime attributable risk was approximately 3 and 5 per 10^5 CT procedures using 2 and 16 CT scanner respectively. The Hereditary risk was 1 and 2 per 10^6 CT procedures for using 2 and 16 CT scanner respectively also. The study concludes that the lifetime attributable risk and hereditary risk increases with increase in the number of CT slices and the amount of absorbed radiation dose. Thus, notwithstanding how low a radiation exposure rate could be it can still necessitate malignant lesions.

CONSENT

As per international standards or university standards, patient(s) written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

In line with the Helsinki declaration ethical approval for the study will be obtained from the ethical committee of the Rivers State University Teaching Hospital Health Research Ethics Committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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