RADIATION DOSE FROM EXPOSURE TO COMPUTED TOMOGRAPHY SCAN OF THE BRAIN IN A REFERENCE HOSPITAL IN NIGERIA

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ABSTRACT

BACKGROUND: Diagnostic reference levels have been set by relevant regulatory agencies in different countries as a result of the biological risks from exposure to ionizing radiation. However, no study has been carried out in our centre to generate data that may come in handy in establishing a local reference level. **OBJECTIVE:** To quantify the absorbed dose from Computed Tomography (CT) scan of the brain using the CT dose chart and thermoluminescent dosimeters (TLD) with a view to establishing local diagnostic reference levels (DRL) for our centre. **METHODS:** A prospective, cross-sectional study involving 30 patients aged 4 months to 72 years referred for brain CT. Patients were positioned according to standard protocols for brain CT. Two TLD chips were placed on the glabella and occiput respectively. The posterior one was held in place by the weight of the head while the anterior one was held in place with tape. With an azimuth of 180°, the posterior TLD was marked as 'entrance' and the anterior as 'exit.' The TLDs were only detached at the end of the investigation. They were sealed separately in small transparent cellophanes bags and sent for reading at a regional radiation dosimetric laboratory. Simple statistical tools were used to determine central tendencies. **RESULTS:** The absorbed radiation dose noted in our centre had a range of 38.6 - 66.4 mGy (1.93-3.32 mSv) from CT dose chart and 0.6-104 mGy (0.03-5.20 mSv) for TLD respectively. The mean collective dose for CT (50.3 ± 10.2 mGy; 2.52 ± 0.51 mSv) was slightly higher than for TLD (40.83 ± 26.4 mGy; 2.04 ± 1.32 mSv). A paired-sample t-test at a probability level of $p < 0.05$ (for significance) yielded a p-value of 0.05 indicating that there is a statistical significant difference between both means. **CONCLUSION:** The dose from our practice is within the range got from other studies. However, further dose reduction is possible with a more careful technique.

Keywords: Radiation, dose, Computed Tomography, TLD

Introduction

The trend of increasing population exposure to medical diagnostic sources of radiation, attributed to the growing use of computed tomography scans has raised concerns about exposure to radiosensitive organs.[1] In medical imaging, CT is the most important contributor to patient exposures.[2] Although the radiation exposure from computed tomography scans is substantially lower than that from radiotherapy, multiple computed tomography scans could result in non-trivial cumulative doses to radiosensitive organs like the thyroid and eyes.[1]

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The benefits derived from a properly conducted CT procedure will continue to outweigh the small risks associated with it, nonetheless, it is important to be able to specifically quantify the risks.[3] However, assessing the magnitude of exposure or potential risks from diagnostic procedures is a task most physicians find difficult to do.[4]

Effective dose, which is a risk-weighted measure of radiation to organs in the body associated with radiological examination, is considered a good indicator of radiological risk. While methods to calculate effective dose have been established they depend heavily on the ability to estimate the dose to radiosensitive organs from the radiological procedures. The determination of the radiation dose to these organs is very difficult, and direct measurement is not possible. Therefore organ doses are estimated from measurable quantities such as normalized organ dose data expressed as absorbed dose.[3]

The International Commission on Radiological Protection advices that Diagnostic Reference Levels (DRLs) be established. These DRLs are used in medical imaging with ionizing radiation to indicate whether, in routine conditions, the patient dose or administered activity (amount of radioactive material) from a specified procedure is unusually high or low for that procedure. The present International Commission on Radiological Protection (ICRP) advice does not specify quantities, numerical values or details of implementation for DRLs. ICRP considers that any reasonable and practical approach, consistent with the advice, will improve the management of patient doses in medical imaging.[5]

There has recently been some emphasis on conducting more localized studies of patient dose and associated risk estimate from radiological examinations taking into account the specific machines and departmental protocols that could help in establishing reference levels for monitoring dose from such radiological examinations. Although, works by researchers from other centres certainly provides an excellent resource for evaluating doses from radiological examinations, a local study could provide more relevant information. This will help to establish some reference and guidance dose values and would allow us to monitor any changes over time that might arise from aging equipment or changing protocols. It could also give us a means to compare doses with that of other hospitals and regions.[3] Several European countries have established DRLs[6] but this is not the case in our environment. Our work is aimed at generating data that may be useful in establishing local DRL.

Materials and Methods

A prospective, cross-sectional study involving 30 patients aged 4 months to 72 years referred for brain CT between June 23 to July 7, 2014. A 32-slice Toshiba CT scanner that became operational in 2013 was available at the centre. Coded TLD chips (TLD LiF-100) were calibrated using Harshaw 4500 dual TLD reader and supplied by a regional Centre for Energy Research and Training. Patients were positioned according to standard protocols for brain CT. A TLD disk was placed on the glabella and another on the occiput respectively and held in place with tape. They were only detached when the examination for each patient was terminated. Exposure factors were 150 kVp and 150 mAs for >10 years and 150 kVp and 135 mAs for ≤ 10 years. An azimuth of 180° was selected to ensure penetration through the occiput and to minimize eye dose. The posterior and anterior TLDs were subsequently tagged as 'entrance' and 'exit' respectively. When detached the TLDs were carefully sealed in tiny transparent cellophane bags and sent for reading at the standard radiation dosimetric laboratory of the regional Centre for Energy Research and Training that supplied them. Descriptive statistical tools were used to determine central tendencies. A tissue weighting factor of 0.05 (as recommended by the ICRP) for brain was used to convert the absorbed dose (in mGy) to effective dose (in Sievert).

Results

A total of 30 patients participated in the study with 30% (n=9) having an additional contrast investigation and 70% (n=21) having no contrast administration. The age of the patients and absorbed dose as established by both the CT dose chart and TLD is

summarized in (Tab. 1). A comparison of some studies on absorbed dose done by other researchers is given in (Tab. 2).

S.No	Age (Years)	Absorbed dose CT (mSv)	Absorbed dose TLD (mSv)	Contrast
1.	25	2.49	2.904	Contrast
2.	13	2.54	2.207	Contrast
3.	3	3.31	5.099	Contrast
4.	30	3.31	1.512	Contrast
5.	71	3.30	2.419	Contrast
6.	72	2.50	2.9	Contrast
7.	50	2.14	0.6631	Contrast
8.	25	3.31	1.6	Contrast
9.	45	3.31	2.3	Contrast
10.	38	2.96	0.055	
11.	45	2.91	0.784	
12.	47	2.17	2.927	
13.	46	2.21	3.415	
14.	0.33	2.21	1.334	
15.	0.92	1.93	1.142	
16.	9	1.93	2.969	
17.	1	2.16	0.182	
18.	22	2.1	0.028	
19.	55	2.1	2.455	
20.	70	2.90	1.14	
21.	55	2.16	2	
22.	58	3.14	2.8	
23.	67	2.22	3.401	
24.	65	2.22	1.3	
25.	67	1.93	1.1	
26.	28	1.93	2.9	
27.	55	2.16	2	
28.	33	2.54	2.3	
29.	12	3.32	5.2	
30.	62	2.09	0.2	
Mean	**29.00 ± 23.6**	**2.5157 ± 0.51**	**2.0412 ± 1.32**	

Table 1: Effective dose characteristics of the patients

Authors	Location	Dose (mSv)	Sample size	kVp maximum	mAs maximum
Present study	Nigeria	2.5	30	150	150
Origgi et al[7]	Italy	1.8	56	140	580
Osei et al[3]	Canada	1.8	94	138	100
Ogbole et al[9]	Nigeria	2.8	50	120	215
Brix et al[8]	Germany	2.8	9,000	122	317

Table 2: Comparison of absorbed doses

Discussion

The result of our study established a mean effective dose of 50.3 ± 10.2 mGy; 2.52 ± 0.51 mSv for our population using computed tomography dose chart and 40.83 ± 26.4 mGy; 2.04 ± 1.32 mSv when measured by TLDs. It was noted that globally the mean effective dose for brain CT ranged between 1.8 to 2.8 mSv (Tab. 2). The maximum value got from our study as indicated by CT dose chart was 2.5 mSv, an indication that absorbed dose in the course of our practice at our centre falls within acceptable limit. As expected, CT dose chart gave a higher value than TLD although the range was quite narrow. A paired-sample t-test yielded a t-value of 2.044 indicating that there is no statistically significant difference between both means. Also, it should be noted that values reported by CT dose chart do not take into account patient size or dose-reduction techniques such as automatic exposure control incorporated into the system and implemented during the study.

Our CT scanner is a 32-slice machine. As a conscious dose-reduction technique we do not exceed 150 mAs for adults. Getting 2.5 mSv as the mean effective dose gives hope that with a further reduction in exposure parameters without compromising resolution, a further reduction in dose is possible. In a survey carried out in Germany to investigate dose from single slice and multi-slice CT scanners the authors noted that brain CT accounted for the most frequent investigation (27.1%). They subsequently established a mean collective effective dose of 2.8 mSv (Tab. 2) for their population and concluded that considerable dose reduction was observed when single-slice CT was used to examine patients.[8] The reduction in our dose rate compared to theirs may not be unconnected with the much lower mAs of 150 we used as against the 317 mAs used by them. It is apparent that aside using single-slice CT, a reduction in exposure parameters like mAs may possibly reduce dose.

A similar work done in our locality to determine the dose of CT examinations and provide a template for dose optimization concluded that CT doses in their centre were high. They established an effective dose of 2.8 mSv,[9] the highest seen in literature consulted by us (Tab. 2). Their sample size was 50 CT brain patients and the maximum mAs was 215. Their machine was also multi-detector like ours. Their finding possibly validates our thinking that in this locality there is a need to pay conscious attention to dose-reduction techniques. Examples from other climes shows some reduction in dose levels irrespective

of the type of CT machine used.

In a closely-similar work carried out in Netherlands using multi-detector CT which involved 186 patients, a mean effective dose of 1.5 mSv was established for brain CT.[2] Although the mAs values for the investigations were not given, it was likely that the mAs was considerably reduced to have arrived at such low level of effective dose. Another work used a maximum mAs of 100 on 94 patients and derived a mean effective dose of 1.8 mSv and 1.1 mSv for for adult and pediatric head CT examinations respectively.[3] In our work however, we got much higher values for pediatrics (Tab. 1) probably because of the 135 mAs we used which is considerably higher than that reported by Osei.[3] An effective dose of 1.8 mSv was got from single-slice CT used on 56 patients in Italy. A surprisingly high mAs of 580 was used yet their value was lower than that got from our study. This buttresses the argument of Brix et al,[8] and consolidates our thinking in that regard.

Conclusion

A mean effective dose of 2.5 mSv for brain was noted in our centre. Although this did not differ significantly from values got from other works further dose reduction is possible with careful and conscious dose-reduction practices. We also noted that dose values generated by TLDs were lower than that got from CT dose chart and the difference is statistically significant. Many of our volunteers were neither ambulant nor could stand erect. This was a limitation as weight assessment could not be made. The TLD chips could also not be adjusted on the patients to correspond with each slice thickness selected and hence receive optimum irradiation. This mostlikely contributed to the lower values got. The authors also acknowledge the fact that our sample size was small compared to other studies, this is due to low patient through put to the centre. This does not however negate the findings of this study.

We recommend further assessment of patients using further reduction in exposure parameters to track changes in dose levels, if any.

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