EVALUATION OF EFFECTIVE DOSES FOR PAEDIATRIC BRAIN COMPUTED TOMOGRAPHY AT AMINU KANO TEACHING HOSPITAL,KANO STATE NIGERIA

Hauwa Aliyu umar, Richard Emmanuel, Isma'ila Baba
Department of medical radiography Faculty of Allied Health Sciences College of health sciences Bayero university Kano
Email: hauwaumar1994@gmail.com, Tel: +2348033389643

Abstract

Background: Radiation exposure due to computed tomography (CT) is on the increase due to number of different CT examinations worldwide .Computed tomography is a valuable modality for diagnosing many paediatrics disease conditions. Paediatric patients are considered to be at higher risk of developing radiation-induced tumors due to increased tissue Radio-sensitivity.

Aim: to evaluate effective dose of paediatric patients in Aminu Kano Teaching Hospital and to estimate lifetime attributable cancer risk .

Materials and method: Computed Tomography Dose Index volume (CTDIvol) and Dose Length Product (DLP) were obtained from the CT console. Effective Dose (ED) was calculated using DLP x age specific conversion factors recommended by ICRP 60. Cancer risk was estimated by multiplying ED in each age group by the Biological Effects of Ionizing Radiation (BEIR) VII conversion factor report The most recent standardized BEIR VII conversion factor (0.0001/mSv) was used.

Results: Calculated mean CTDIvol was 46.85mGy mean DLP was 1825mGy.cm and mean ED was 6.8mSv for all paediatric patients. Cancer risk for neonates (<1years) was 85 in 100,000 population .And for the older age groups (>10years) was 58 in 100,000.

Conclusion: The Radiation doses were found to be higher when compared to standard reference levels.

Keywords: Paediatrics, Radio-sensitivity, Radiation and Computed tomography

Introduction

There is an increased global demand for computed tomography (CT) Compared with plain- film radiography, CT accounts for relatively large doses of ionizing radiation, with CT exposure currently representing the largest man-made contribution of absorbed dose to the general population [1] . Monitoring of CT radiation dosage is therefore of increasing importance, especially in paediatric imaging, as children are more susceptible to the harmful effects of ionizing radiation [1].

An international (IAEA) study has shown that some countries are over-exposing children to radiation when performing computed tomography (CT) scans. These children are receiving adult-sized radiation doses. In addition, the study showed that paediatric CT scans occur more frequently in Africa than in Asia and Eastern Europe. The frequency has been attributed to the limited availability of alternative medical imaging techniques, such as MRI (magnetic resonance image) and ultrasound, which do not involve ionizing radiation, or because some CT scans are performed unnecessarily [2]

The combination of using adult parameters and the higher radiation risk for children compared with adults leads to a significantly higher attributable lifetime cancer mortality rate in children (Brenner et al., 2001a). According to Brenner et al. (2001a), based on

600,000 abdominal and head CT scans performed annually in the US on children under the age of 15 years, approximately 500 of these children might ultimately die of radiation induced cancer [3].

Children are ten times more sensitive to the effects of radiation than middle-aged adults and girls are more radiosensitive than boys. sites showed that 8% of all diagnostic imaging procedures were CT scans, out of which 15% are pediatric CT scan examinations.(Kisembo *et al* 2015) . There are several strategies to limit CT radiation doses, which include performing necessary examinations, limiting the region of coverage and adjusting individual CT settings based on indication, region imaged and size of the child[4].

The use of CT scanning in paediatric radiology departments has increased rapidly worldwide over the past 15 years. kharbanda *et al*.(2015). CT is now a standard modality in assessing a variety of disorders in children as well as for cancer detection and surveillance, and evaluation of trauma and inflammation [5]. There has been overwhelming increase in the availability of use of CT scans in Nigeria. As such this study therefore, aimed at assessing the effective doses as well to estimate future cancer risks in paediatric patients undergoing brain CT examinations at AKTH.

Materials and Method

This study was a prospective design and was carried out in the radiology department of Aminu Kano Teaching Hospital (AKTH) .This study was conducted for a period of 6months from march 2018-september, 2018.convenience sampling technique was adopted for the study. Aminu Kano teaching hospital (AKTH) Kano state, Nigeria is located northwest on latitude 11^0 15^I and longitude 8^0 29^I of Nigeria.The hospital provides specialist and general medical services to patients from Kano metropolis and the various Local Government Areas surrounding it. Primary source of was used in the study being prospective, the data was obtained from the recorded information displayed on the CT console at Muhammadu Sunusi radio-diagnostic centre in AKTH. All pediatric patients that underwent brain CT at Muhammad sunusi radio-diagnostic centre that met with the inclusion criteria were enrolled in the study. A 164-slice Toshiba Aquilion CT scanner was used to obtained data. It was in year 2008 that the CT machine was manufactured and was installed in 2015.It has a maximum kVp of 140 and maximum tube current of 400mA and inherent filtration of 2.7 Al equivalent. Data collected on patient related parameters include age, sex. Exposure related parameters includes kilovoltage (kV), tube current, and exposure time (mAs), slice thickness, scan length, pitch, as well as CTDIvol and DLP recorded on the CT using was extracted and recorded using a data capture sheet designed for the study. patient demographic information namely, Gender, age was also recorded from the radiological examination request card. The CT scan machine calculates and stores automatically the CTDIvol and DLP doses of each CT examination carried out in the CT console. This data was prospectively recorded using a data capture sheet from the console respectively. CTDIvol and DLP were obtained from the CT console, effective dose was calculated by using E=K(conversion factor) x DLP .The conversion factors were derived from ICRP 60(2005) Age-specific conversion factors to obtain respective effective doses. The Lifetime attributable risk (LAR) was estimated by multiplying averages of effective dose for each of the age-groups. The most recent standardized BEIR VII conversion factor (0.0001/mSv). It was developed in the National Academies' Biological Effects of Ionizing Radiation (BEIR) VII Report, to estimate the lifetime

attributable risk (LAR) incidence The model is based on pooled analyses of Japanese atomic bomb survivors and other medically exposed cohorts, and it employs a linear non-threshold risk model for low-dose radiation, such as medical X-rays, assuming that the cancer incidence is linear relative to the radiation dose. Additionally, this LAR model assumes a period of 5 years selected as the minimum latency for solid cancer [6].

All data were analyzed using SPSS Version 20.0, Chicago Version. Ethical approval was obtained at Aminu Kano Teaching Hospital Research ethics committee before commencing the study.

Radiation dose measurement

CTDIvol and DLP were obtained from the CT console, effective dose was calculated by using E=K(conversion factor) x DLP .The conversion factors were derived from ICRP 60(2005) Age-specific conversion factors to obtain respective effective doses.

Table 3.11.2 showing conversion factors used

Age groups	ICRP (60) Conversion factors
0-6month	0.0110
6month-3years	0.0067
3-6years	0.0040
6-10years	0.0032
>10years	0.0021

Results

A total number 0f 93 paediatric patients were prospectively enrolled in the study,comprising of 43 females and 50 males with mean and standard deviation of 6.74±4.78 .The age ranged from(less than 1year) 0-15years. The scan length ranged from 14-35cm. The kV ranged from (100-120), mA from (100-300) and rotation time of (0.5- 0.75) seconds. The percentages of male and female was 53.8% and 46.2% respectively.

Table 1: Comparison Of This Study With Standard Diagnostic Reference Level According To European Commission (2015)

AGE GROUPS	**DLP**	**THIS STUDY**	**CTDIvol**	**THIS STUDY**
<1	270-340	839.7	20-27	28.9
1-5	270-600	1670.1	25-40	42.9
6-10	105-370	1784.0	35-40	48.9
>10	200-205	2521.0	50	50.

Table 2 :Comparison of this study with Standard Reference Level for different Countries (Mulkens, Salgado And Bellinck, 2012)[6]

country	CTDIvol (mGy) according to Age groups <1(y)	1-5(y)	5-10(y)	>10(y)
Switzerland(2005)	20	30	40	60
Germany(2006-2007)	33	40	50	60
UK(2003)	30	45	50	65
Belgium(2007-20009)	35	43	49	50
Objective dose Optimization 2011	20	25	30	30-35
This study	28.56	42.81	48.9	58.85

Table 3 :Comparison of other Studies done with this present Study

AUTHOR/YEAR	SAMPLE SIZE	AGE RANGE	CTDI (mGy)	DLP (mGy.cm)	E.D (mSv)
Vawda *et al* 2015	30	0-10y	30-32	488-563	-
Vilar *et al* 2016	-	<1-15y			
		<1	-	-	1.7
		1-5	-	-	1.6
		6-10	-	-	1.8
		11-15	-	-	1.6
Sadigh *et al* 2015	100	<18	36.1	583.6	-
Buls *et al* 2010	-	<1-15y			
		<1	35	280	-
		1-5	43	473	-
		5-10	49	637	-
		10-15	50	650	-
Nitika *et al* 2015	-	2-16y	32.03	748.14	3.345
Kharbanda et al 2015	255	1-15y	-	-	2.68
Zoretic *et al*2014	138	<1-18y	36.8±6.31	712±92.6	1.06-7.38
Brady *et al* 2012	-	0 ->10y			
		0-6m	18	250	2.4
		6m-3y	20	200	1.9
		3-6y	30	450	1.7
		6-10y	40	650	1.9
		>10y	45	700	1.4
Saravanakumar *et al*.2017	-	<1-5y			
		<1y	20	352	-
		1 -5y	38	505	-
This study	93	0- 15y	46.85	1825	6.8
		<1	28.56	839.7	8.56
		1-5	42.81	1670.0	7.76
		6 -10	48.90	1784.0	5.79
		>10	58.85	2821.0	5.82

Table 4: Mean Radiation doses of all Paediatric Patients

AGE	MEAN CTDIvol(mGy)	MEAN DLP(mGy.cm)	MEAN E DOSE(mSv)
<1-15Years	46.85	1825	6.8

Table 5 :Lifetime attributable Risk for each age group

AGE GROUPS	E D	LAR	PERCENTAGE (%)
<1	8.53	0.00085	0.009%
1-5	7.76	0.00078	0.008%
6-10	5.79	0.00058	0.006%
>10	5.82	0.00058	0.006%

Discussion

The role of ionizing radiation in the promotion of human health is very similar to a double-edged sword. The radiation safety and risk-benefit ratio of various interventional radiological procedures, especially those with a higher dose of radiation such as CT scanning, need a fairly critical evaluation [7].

Correlation of doses obtained from this study with standard DRL recommended by the European commission (2005) was presented in table1. it observed that DLP values for different age groups was far higher than DLP values formulated by the EC, this can be attributable to longer scan length from our study which ranged from 14-35cm. More so CTDivol was a bit higher than those from EC. Highest DLP and CTDvol was observed in >10years and lowest was observed in <1years.these goes in line with studies by buls *et al.* 2010 in which 0-15years of age was selected where highest CTDIvol and DLP was observed in 10-15years,CTDIvol(50mGy)and DLP(650mGy.cm).lowest scan length was 16.5cm while the highest was 17.8cm from studies by vawda *et al*. 2016[8] for 0-10years of age selected for the study .CTDIvol and DLP increases with increased age for this study which is in line with studies by su *et al.* 2016, saravanakumar *et al* 2017 and brady *et al.* 2012.

Comparison of CTDivol from this study was done in Table 2 with CTDivol reference levels for different countries .lowest dose of CTDivol was found to be lower in objective dose optimization (Belgium, 2011).it depicts that as age increases CTDivol increases .this goes in line with studies of Brady (2012)[9].Across the Age groups CTDivol was found to be lower than this study in Switzerland and dose optimization in Belgium .While lower CTDivol was found to be higher than from this study in Switzerland Germany and UK.

Table 3, shows other studies done in comparison with this study. Vilar *et al.*2016.[10] studies and this study shows similar trend in which the highest Effective Dose was found within the lowest age groups (neonates) which were <1year 1.7mSv.and lowest ED was observed in 11-15years and 1-5 years age groups which is 1.6mSv respectively .however in this study Effective Dose between 6-10years was highest and with slightly increased in >10years which is 5.82mSv.from our study mean effective dose deviates from findings by kharbanda *et al*[11] and Nitika *et al* [12] in which the effective dose was lower which are 2.68mSvand 3.345mSv.both studies stated that as Age increases Effective dose decreases .This could be as a result of variability regarding the protocols and radiation exposure to paediatric within the age group of >10years.

The mean CTDivol and DLP from this study are significantly higher than studies by Sadigh *et al*[13], which shows lower value of mean CTDIvol and DLP across all age groups the mean CTDivol and DLP was 36.1mGy and 583.6mGy.cm respectively. This shows that the mean doses from this study are far higher and could be as a result of different scanning protocols.

According to Buls *et al* [14], CTDivol and DLP values for <1years age group was slightly higher than for this study which was 35mGy and 280mGy.cm, for 1-5 years greater than for our study which was 43mGy and 473mGy.cm, while in 5-10years they were closely similar to that of our study which was 49mGy and 637mGy.cm while in 10-15years was lower than that of our study which was 50mGy.cm and 650mGy.cm.

Mean CTDIvol and DLP for all age-groups by Nitika *et al* was lower than for this study with difference of 14.82mGy for the mean CTDIvol the mean CTDIvol for Nitika and our study is 32.03mGy.cm and46.85mGy respectively while mean effective Dose was lower than for this study. Mean Effective dose for all age groups by kharbanda *et al* was 2.68mSv and was found to be lower than for this study which was 6.8mSv [8].

The calculated mean Effective Dose across age groups from this study was found to be within the range from studies by Zoretic *et al* [15] which was 1.06-7.38mSv while for this study is 6.8mSv While the mean CTDIvol and DLP were lower than for this study which were 368±6.31mGy and 712.92±1825mGy.cm.respectively.for this study mean CTDIvol and DLP were 46.35mGy and 1825mGy.cm respectively.

In relation to Brady *et al* [9]studies, CTDivol and DLP for 0-6month (CTDIvol=45mGy and DLP=700mGy.cm) was lower than from this study this could be because of the age grouping .however from 6month-3years & 6-10years effective dose remain same(1.9mSv).Lowest Effective Dose was found to be in highest age groups(>10years age groups)which was 1.4mSv and was different from this study where Effective Dose increased in the highest age group and was found to be 5.82mSv .

Studies by saravanakumar *et al*[16] shows, CTDivol & DLP increased with increased age and was found to be lower than for our study This could be as a result of fewer age groups .The result for saravanakumar *et al* showed mean CTDIvol and mean DLP for <1year was 20mGy and 352mGy.cm respectively and for 1-5y mean CTDIvol and DLP was 38mGy and 505mGy.cm. In table 5 distributions of age groups with their lifetime attributable risk was presented .Age groups of <1 years (neonates) the risk was found to be highest. Risk factor was 0.00085 which means in 85 out 100,000 there will be potentially an excess of cancers observed in a population of 100,000. LAR Equates potential increased run of 0.009% in neonates over base rate risk.

For the higher age group (>10years) the risk was found to be lower (0.00058) which means 58 out of 100,000 will potentially have an excess of cancers observed in a population of 100,000.This shows there will be additional 6 cancers in a population of 100,000.

Conclusion

Radiation doses was found to be higher which is alarming and calls for optimization of paediatric protocol in AKTH.

References

1. Pitcher, R., Akudugu, J. and Groenewald, W. (2012) 'Diagnostic reference levels for Paediatric computed tomography', pp. 10–13. doi: 10.4102/sajr.v19i2.846.
2. Ogbole, G. I. 'radiation dose in paediatric computed tomography : risks and benefits'*journal of ibadan postgraduate medicine*' ,2010 8(2),118–126.
3. Brady Nov,"Assessment of paediatric CT dose indicators for purpose of optimization"(85)(1019):*journal of*

radiology,oncology and all related science :2012, 1488-1498,doi ;10.1259.1259/bjr/28015185

4. Kisembo H, Samson S, Kavuma A, Nakatudde R, Bugeza S. A survey of paediatric CT radiation doses in two selected hospitals in Kampala, Uganda: a radiation safety concern. *Int J Cancer Therapy and Oncology.*2015; 3(3):3327. doi: 10.14319/ijcto.33.27©
5. Isabelle Thierry-Chef , Jéré mie Dabin , Eva G. Friberg , Johannes Hermen , Tore S. Istad ,Andreas Jahnen *et al*. 'Assessing Organ Doses from Paediatric CT Scans *International Journal of Environmental Research and Public Health'* — A Novel Approach for an Epidemiology Study (the EPI-CT Study) , (2012) 717–728. doi: 10.3390/ijerph10020717.
6. Yin-Ping Su , Hao-Wei Niu, Jun-Bo Chen, Ying-Hua Fu.Jan 'Radiation Dose in the Thyroid and the Thyroid Cancer Risk Attributable to CT Scans for Pediatric Patients in One General Hospital of China' *International Journal of Environmental Research and Public Health,* 2012, 2793–2803. doi: 10.3390/ijerph110302793
6. Mulkens, T., Salgado, R. and Bellinck, P. (2012) 'Dose Optimization and Reduction in CT of the Brain and Head and Neck Region'. doi: 10.1007/174.
7. Nader Ghotbi,,Mariko Morishita, Akira Ohtsuru, Shunichi Yamashita Article, R.'Stefano Colagrande, Daniela Origgi, Giovanna Zatelli,Andrea Giovagnoni, Sergio Salerno, 'CT exposure in adult and paediatric patients : a review of the mechanisms of damage , relative dose and consequent possible risks'. *journal of medical physics radiobiology and safety"* 2014 , (10).123-125. doi: 10.1007/s11547-014-0393-0.
8. Vawda Z, Pitcher R, Akudugu J, Groenewald W. Diagnostic reference levels for paediatric computed tomography. *S Afr J Rad.* 2015;19(2); Art. #846, 4 pages. http://dx.doi. org/10.4102/sajr.v19i2.846
9. Z Brady,phD,F Ramanaukas ,DCR(R),T M Cain,MB BS,FRANZCR, Nov,"Assessment of paediatric CT dose indicators for purpose of optimization"(85)(1019):*journal of radiology,oncology and all related science* :2012,1488-1498,doi ;10.1259.1259/bjr/28015185
10. Gorge Vilar-Palop, José Vilar, Ildefonso Hernández-Aguad, Isabel González-Álvarez, Blanca Lumbreras 'Updated effective doses in radiology', *Journal of Radiological Protection;2016,* (6), 2009–2015. doi: 10.1088/0952-4746/36/4/975.
11. Anupam B. Kharbanda, MD, MSc, Ernest Krause, Yi Lu, MS, and Karen Blumberg, MD 'Analysis of Radiation Dose to Pediatric', *journal of of society for academic emergency medicine.*2015, 670–675. doi: 10.1111/acem.12689.
12. MS Nitika C. Panakkal , Mr Sushil Yadav and MS Winniecia Dkhar" comparison of effective dose between adult and paediatric ct brain using dose length product "*International Journal of Pharma and Bio Sciences'* 2015 ; 6(4): (B) 37 - 42 ISSN 0975-6299
13. Gelareh Sadigh MD, Nadja Kadom1 MD; Donald Frush MD FACR FAAP;Mythreyi Chatfield; Debapriya Sengupta; Karthik Priyadrashini; Keith Straus National variation in paediatric non contrast head ct '*journal of amerian college of radiology'2015 ;204(3):W293-301*
14. N Buls, Brussel H Bosmans, Leuven C Mommaert, Bel V F Malchair, P Clapuyt, Cliniques Saint-Luc P Everarts, Centre Hospitalier de Jolimont-Lobbes February,2010
15. AW-Zoretic, D.Seth, G.Katzman, S.Sammet; "Estimation of effective dose and lifetime attributable risk from multiple head CT scans in ventriculoperitoneal shunted children.*US national library of, medicine* .83(10),2014, 1920-1924 doi.10.1016/j.ejrad.2014.07.006
16. Saravanakumar, K.Vaideki, K.N Govindarajan, S. Jayakumar, and B.Devanand, Asessment of regional paediatric CT indices in Tamil Nadu "*journal of medical physics,*2017*,* 42(1): 48-54 doi .10.4103/0971-6203.202425