Computed tomography scanningparameters and radiation doses inpaediatric patients at Muhimbilinational Hospital

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COMPUTED TOMOGRAPHY SCANNING PARAMETERS AND RADIATION DOSES IN PAEDIATRIC PATIENTS AT MUHIMBILINATIONAL HOSPITAL

By

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A Dissertation Submitted in Partial Fulfillment of the Requirements for Degree of Master of Medicine in Radiology of

Muhimbili University of Health and Allied Sciences
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CERTIFICATION

The undersigned certifies that he has read and hereby recommends foracceptanceof dissertation entitled **"*Computed tomography scanning parameters and radiation doses in paediatric patients at Muhimbili National Hospital*:"** In partial fulfillment of the requirements for the degree of Master of Medicine in Radiology of Muhimbili University of Health and Allied Sciences.

Dr. MechrisMango

(Supervisor)

_____

Date

DECLARATION AND COPYRIGHT

I, Japo M. Lukali, declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other university for similar or any other degree award.

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DEDICATION

I dedicate this work to my late lovely mom, love you always.

ABSTRACT

Background

Computed tomography (CT) examinations have been increasing since its evolution in 70's. Although it provides good contrast resolution and rapid scanning, it leads to larger doses of ionizing radiation compared to conventional x-ray. Children have much risk from a given radiation dose than adults both because they are more radiosensitive and they have longer life time in which a radiation-induced cancer could develop. CT scanning parameters are the main determinants of radiation dose received by the child; therefore it is important to adjust them according to child's age and body size. The aim of this study is to determine CT scanning parameters and radiation doses for pediatric patients according to age and body size at MNH.

Broad objective

To determine Computed Tomography scanning parameters and radiation doses in pediatric patients at Muhimbili National Hospital.

Methodology

This is a hospital based cross sectional study which was conducted at Radiology department, Muhimbili National Hospital from September 2017 to March 2018. Children referred for CT scan were included in the study following informed consent from the parents/guardians. Children underwent CT examination by using a Siemens Somatom Definition Flash, Frank furt, Germany model dual tube with 128 slice, 64 slices each tube .Structured questionnaires were used for recording patients' demographic data, clinical indication of CT, and scanning parameters. CT dose estimation was calculated from CT dose calculator computer software supplied by Imaging Performance and Assessment of CT scanners (ImPACT). Data analysis was done using the Statistical Package for Social Sciences (SPSS) version 20. Statistical Association was done by using cross tabulations. P value of < 0.05 was considered statistically significant.

Results

The mean age of the study participants was 6.3years with a range of 0.01-15 years. Majority of children were males, and the majority of children were from age group of 1-5 years.

Head trauma was the commonest indication with the majority patient aged 6-10years.Sixty four percent (112/174) of the CT examinations were of the head, twenty six percent (45/174) were of abdomen and ten percent (17/174) were of the chest.

The tube potential and tube current for head examinations were higher than for the chest and abdominal examinations. The mean tube potential and tube current for the head were 115.4kVp and 209.45mA respectively with no evidence of adjustment based on body size and age of the patient. The mean tube potential and tube current for chest and abdomen were adjusted for paediatric body size and age with the mean value of 84.52 kVp and90.42kVp for the tube potential and 126.5mA and 91.25mA for tube current respectively.

The doses for Head CT examinations were higher compared to the chest and abdomen, the mean CTDIvol(mGy) 11.78, DLP(mGy.cm) 231.42 andCTDIw (mGy) 16.6, but relatively lower than other international values.

The calculated meanCTDIvol 11.8, 0.89, 1.79 and DLP 232.6, 36.5, 86.5 for head, chest and abdomen respectively were significantly lower than the values displayed on the console i.e. 36.7, 2.7, 2.6 CTDIvol and 731.7, 78.6, 114.8 DLPs.

Conclusion

Scanning parameters for head CT examinations are not adjusted for paediatric examinations. The use of large tube potential and tube current for head examinations has led to large doses for head examinations. The radiation dose mean values for CTDI vol, and DLP were significantly lower than those from other countries, however lowest doses have been reported to IAEA. We therefore still have the chance to further reduce our doses to the lower levels than these so as to reduce the level of radiation to our children.

Recommendations

1.The use of recommended scanning parameters for head CT examination such as low tube potential (kVp) and low tube current in paediatric imaging should be adhered**.**

2. Further CT dose reduction is needed despite the fact that our doses are lower compared to many other international values. This is because we need to minimize the radiation dose to children to as low as reasonably achievable. .

3. Further studies with larger sample size should be conducted all over the country involving different CT centers, using this study as a base line to develop Diagnostic reference levels for paediatric CT examinations.

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LIST OF ABBREVIATIONS

ALARA	–	As Low as Reasonably Achievable
CT	–	Computed tomography
CTDI	–	Computed Tomography Dose Index
DLP	–	Dose Length Product
DRL's	–	Diagnostic Reference Levels
IAEA	_	International Atomic Energy Agency
MNH	–	Muhimbili National Hospital
PACORI	–	Pan African Congress of Radiology and Imaging
Tshs	–	Tanzanian shillings
UNSCEAR	–	United Nations Scientific Committee on the Effects of Atomic radiation

DEFINITION OF TERMS

1. X-ray tube voltage (kVp) - Is the peak energy of the x-ray beam
2. Tube current – Is a measure of radiation produced (milliamperage) via an x-ray tube.
3. Tube current time product/milliamperage-second (mAs) – Is a measure of radiation produced (milliamperage) over a set amount of time (seconds) via an x-ray tube.
4. Scan length – Is the length of the scanned/imaged body section.
5. Pitch – Table distance travelled in one 360 degree gantry rotation divided by beam collimation.
6. Computed tomography dose index (CTDI) – Is the fundamental CT dose descriptor, it is used extensively toexpress total absorbed dose in CT, the parameter CTDIvol is the more commonly used.
7. Weighted CTDI (CTDIw) – Is the weighted average of dose across a single slice.
8. Dose Length Product (DLP) – Is the associated CTDI quantity for specifying the total radiation to a patient. It is the product of CTDI value and the length of the body area scanned.
9. Diagnostic reference levels(DRL's) - These are the reference values in diagnostic medical imaging used as practical tool to identify situations wherepatient doses are unusually high and in most urgent need of reduction.

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACK GROUND

Computed Tomography (CT)is an imaging modality that uses x-rays and computer processing to produce rapid, consistent and detailed information (through images) of the tissue density in slices through the patient'sbody. X-rays are one form of ionizing radiation used in computed tomography (CT) scanners and other x-ray devices. Since its introduction in 1970's, the use of CT has increased rapidly; this is because it is noninvasive and has high contrast resolution. Despite the fact that CT produce high contrast resolution, it uses larger doses of ionizingradiation compared to conventional x-ray resulting in a marked increase in radiation exposure in the population(1).

Exposure to ionizing radiation may induce two types of effects namely Stochastic and Deterministic. Deterministic effects results fromshort term, high level (large dose) radiation exposure referred to as ''acute exposure". These effects usually appear quickly and include burns, hair loss, cataractand radiation sickness. These occur only if the radiation dose exceeds a certain threshold, and the magnitude of effect is directly proportion to the size of the dose. Stochastic effects are typically associated with long term, low-level (chronic) exposure to radiation. The effect increases as the radiation dose increases, but the severity of the outcome is independent of the dose. The probability of cancerdevelopment will therefore increase with radiation dose even for low dose medical imaging procedures (1)

The primary stochastic effects are cancer and genetic defects (mutations). Stochastic risks are of special concern in pediatric imaging because children are more sensitive to the effect ofionizing radiation than adults and have longer life span to develop long- term radiation induced health effects like cancer (2)(3) Fatal cancer induction is the most serious effect of ionizing radiation (4)

Most of the quantitative information about the risk of cancer induced by ionizing radiation isobtained from follow-up studies of a cohort of more than 35,000 atomic bomb survivors who had received low doses of radiation comparable to the dose of a single helical CT scan (5) CT isof special interest due to its relatively high radiation dose and wide use.

CT use in children has drawn more attention because children are at greater risk of radiation exposure than adults due to their rapidlydividing cells which tend to be more radiosensitive, and also children have a longer expected life time in which potential radiation injury can develop(6). Although the individual radiation risks are quite small, radiation protection in pediatric imaging is a public health problem because of large number of children exposed to those risks (3). The use of computed tomography in pediatric patients continues to grow despite evidence on known risks of CT- related radiation including induction of fatal cancers in children.

About 4 million pediatric CT scans of the head, chest, abdomen and spine are performed each year in United States, and these are projected to cause 4870 future cancers(7). In African countries the number of pediatric CT examinations per year are relatively higher compared to Asia and Eastern Europe (8). In one of the largest teaching hospital in Nigeria, the records show that the proportion of CT studies that are currently performed in children range between 14% and 18%(9).A study done in Uganda in 2014 revealed that the frequency of pediatric CT is increasing with majority of examinations being performed in children 0-4 and 10-14 years(10). A study conducted by Muhogora et al in 2010 showed that the frequency of CT scan examinations per year in Tanzania was 3828, of which 587 were performed in children constituting about 13% of total CT scan examinations(8).

Since the frequency of pediatric CT examinations is rapidly increasing and estimates suggest that quantitative lifetime radiation risks for children are not negligible, efforts should be made towards more active reduction of CT exposure parameters in pediatric patients. In recent years, radiation protection from pediatric CT revealed increased attention in international medical community. The United States Food and Drug Administration (FDA) published asset of recommendations in order to keep radiation doses during CT as low as reasonably achievable, especially for pediatric and small adult patients. They insisted on the importance of adjusting CT scanner parameters appropriately for each individual's weight and size, and for the anatomical region being scanned. The Image Gently Alliance for radiation safety in pediatric imaging was formed in 2007 US, with the primary objective of raising awareness about methods to reduce

radiation dose during pediatric imaging. It recommended the ten steps of image optimization and lowering CT dose for pediatric patients(11)

The AFROSAFE campaign on radiation safety made by PACORI and Radiation health workers in Africa was also formed with the purpose of identifying and addressing issues arising from radiation protection in medicine in Africa(12). Its goal is that all radiation – based procedures are appropriately justified and optimized for maximum benefit to the patient. This was stressed out during PACORI meeting in Dar es salaam 2017.

Various studies in Tanzania were conducted addressing the issue of Radiation protection on CT examination, but none of the study talked about pediatric age group which is the most important one, as children are more vulnerable to the effects of ionizing radiation. This study will be the first to address radiation protection issues in pediatric CT, and therefore its aim is to make sure that the CT scanning parameters and the radiation doses are kept ideal for paediatric imaging. The findings from this study will be disseminated in different CT centers to be used as reference values since we have not yet developed our diagnostic reference values**.**

1.2 LITERATURE REVIEW

The frequency of pediatric Computed Tomography (CT) examination has been increasing all over the world since its introduction in 1970's. CT produces high dose of ionizing radiation and risk of cancer compared to other imaging modalities, particularly in children due to their growing small bodies with increased radiation sensitivity (10,13). In the year 2010 the number of CT scan per year in Tanzania, was 3823, of which 587 were children which comprises of about 13% of total CT scan examinations(8).This is from the study conducted by Professor Muhogora., unfortunately there is no any other study done recently, addressing the issue of paediatric CT in Tanzania**.**

According to 2013/2014 Diagnostic Imaging Dataset Annual Statistical Release from National Health Service Centers in England, the frequency of pediatric CT examinations was higher in females compared to males(14) . A study conducted in United states revealed that the use of CT doubled for children younger than 5 years of age and tripled for children 5 to 14years of age between 1996 and 2010(7) Various studies revealed that the projected life time attributable cancer risk from pediatric CT is higher in girls and younger patients, and more on low age at CT examination(1,15,16)**.** Computed tomography effective doses tend to increase with age for chest and spine examinations but decreases with age for head examinations(1).

Indication/ Justification

It is particularly important that indications for pediatric CT are thoroughly justified in order to reduce unnecessary radiation exposure. About 33- 50% of CT examinations in pediatrics have questionable indications(2)(17). In Saudi Arabia, it was found that only 8.9% of pediatric CT examinations were justified(18)A study done in developing countries found that there is much variations in the frequencies of CT examination in children, which indicate a need of justification of pediatric CT examinations(8). Pediatric CT examinations which lack proper indications lead to unnecessary radiation exposure and therefore increase radiation risk to children.

It is important for the radiologists to review the indications of all pediatric CT scans, and should also be available for consultation when indications are uncertain. It is important as well that all physicians who prescribe CT examinations in children should continuously assess its use on a case by case basis(19). Other non-radiation imaging modalities such as ultrasound and MRI should be considered as alternative in evaluation of pediatric diseases if the indication of CT cannot be justified(2). Various measures to minimize unnecessary exposures to radiation from

CT scanning, including elimination of multiple or medically unnecessary scans have been recommended by different organization(13), therefore Radiologists and other radiology health workers should emphasize that those measures are implemented in order to reduce radiation risks from pediatric CT. It is important that the benefits of CT scan in children far outweigh the individual risks, when medically indicated.

CT Scanning parameters

Computed Tomography scanning parameters are the main contributors of radiation dose and image quality. Many of these parameters can be adjusted to reduceradiation dose, these includes; tube potential(kVp), tube current(mAs), detector configuration, patient positioning, scan range, slice thickness and pitch(20). Adjustment of these scan parametersaccording to age and weight (size-based) is of paramount importance when scanning children, this is because children have small bodies and increased radiation sensitivity. Use of adult CT scanning parameters may result in greater radiation exposure for children(3).Some studies have found that adult exposure parameters were being used in pediatric CT examinations in some countries (8)(20), leading to higher radiation doses.

Tube potential and tube current are the two principal parameters to determine the radiation dose delivered(21) Tube current is the most important scanning parameter for radiation dose optimization, children have smaller bodies compared to adults, therefore need lower tube current to achieve image quality(22). Adjusting the tube current (mAs) should be the starting point for reducing amount of radiation imparted to children. Tube current(mAs) has a linear relationship to radiation dose i.e. it doubles the radiation dose(23).

Tube potential/Peak kilo voltage(kvp) used for pediatric CT examination should be lower than that of adult, therefore 100kVp and sometimes 80kVp are adequate for children rather than 120kVp used in adult(23).

The scan range should be significantly reduced since the larger the scan range the higher the radiation dose (19). A smaller pitch will lead to an increased radiation dose and a larger pitch lower radiation dose. For routine CT examinations a pitch of >1 is generally acceptable but using higher pitches >1.5 can result in artifacts and image noise that is not acceptable(20).

Patient positioning have significant impact on patient surface dose as well as image noise. Improper patient positioning increase both surface dose and image noise(19).

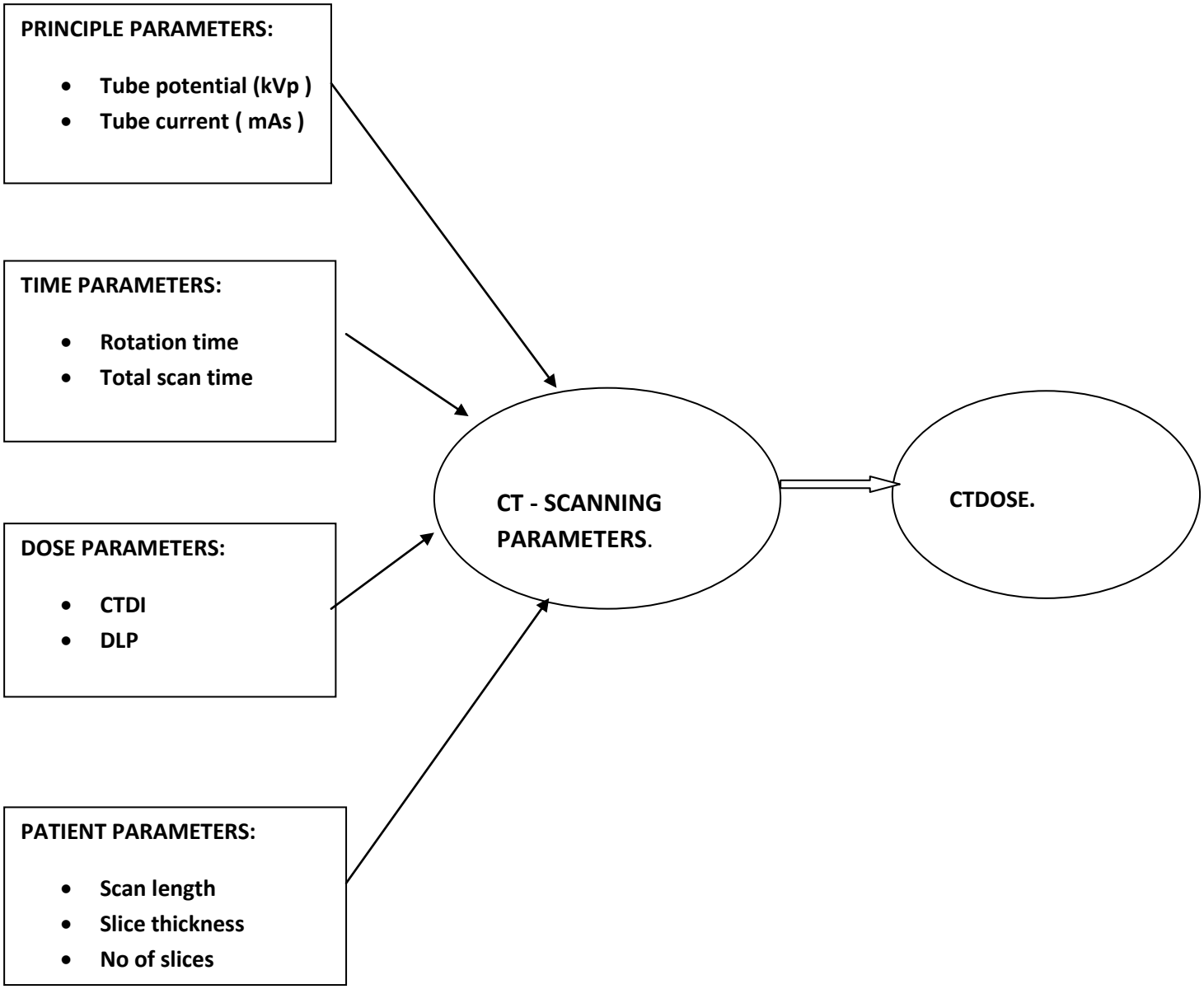
Exposure settings should be customized for children in order to impart lowest radiation dose but providing an image from which an accurate diagnosis can be obtained. Adjustment of scanning parameters during CT examinations in pediatric patients is of great importance lately due to the serious radiation risk involved(10).

CT doses

Computed Tomography doses are marked large enough that there is direct epidemiological evidence for an increase in cancer risk(1). There is now a wide spread concern about this increase in CT doses and several factors contribute to this including the frequency and type of examination. There is great variation in radiation doses from pediatric CT in clinical practice, this suggest an opportunity to reduce doses through standardized protocols(1)(24) It has been found that children received high radiation doses from CT might have a small but significant increase in future cancer risk, this is caused by both use of higher – dose CT and wide variability in radiation doses for each examination(16).

It is important to optimize dose reduction by adjustment of CT exposure factors according to patients age, weight, region scanned and study indication (19) CT dose measurements should be conducted after appropriate period of time and compared with recent studies(24) While CT remains a crucial tool for pediatric diagnosis, it is important to minimize the radiation dose to children to as low as reasonably achievable (ALARA)(9) by using exposure settings customized for children.

1.3 CONCEPTUAL FRAME WORK



1.3 STATEMENT OF PROBLEM

There is an increase in number of CT examinations in pediatric patients in recent years as it has become an imaging modality of choice in evaluating many children diseases, and therefore it has become a major source of medical radiation exposure in children. CT scan examination have higher radiation dose and children have higher radiation sensitivity and increased likelihood for radiation – induced cancer which can manifest later in their life than adults(13). Despite the fact that CT comprise 11% of all radiographic examinations, it accounts for 67% of medically induced radiation exposure, and about 10% of all CT examination are conducted in children aged from new born to 15 years(25). About 4870 future cancers are projected to occur following 4 million pediatric CT performed each year(7).Studies shows that there is poor awareness of radiation doses associated with pediatric imaging examination including CT(8)(26).

Many pediatric CT examinations are conducted using inappropriate scanning parameters. Radiation exposure from inappropriate scanning parameters results in relatively higher dose for a child's smaller cross-sectional area compared with an adult. At Muhimbili National Hospital the scanning protocols are incorporated in the CT machines and the settings involve fixed paediatric age groups, and hence lack weight based protocols. This may lead to relatively higher doses to children with small bodies/weight as opposed to those with larger bodies of the same age. Generally, lack of standard protocol, lack of customized settings and lack of Standard of Procedures (SOP) in paediatric CT imaging are the main reasons to conduct this study. This study will help to identify the scan parameters and doses used for pediatric CT imaging at MNH and therefore it will provide baseline information to the radiology department if adjustments of those scanning parameters and doses are needed.

1.4 RATIONALE

Optimization of CT radiation doses during pediatric imaging is a major radiation protection concern. Due to their small bodies, and rapid cell multiplication, children have increased sensitivity to radiation compared to adults and they have more remaining years of life in which radiation induced cancer may develop. Following AFROSAFE campaign made by PACORI and radiation health workers in Africa with the main objective of identifying and addressing issues arising from radiation protection in medicine in Africa, there is a great need to conduct this research as it deals with radiation protection issues in pediatrics.

Due to great variations in body size in pediatric patients, it is important to adjust the CT scanning parameters, because these parameters are the main determinants of radiation dose received by the child. Therefore the aim of this study is to assess CT scanning parameters and doses for pediatric patients according to age body size and region imaged are being conducted. This study will provide baseline information for subsequent dose reduction or optimization in pediatric CT. Also the results of this study will give a guide and justification for developing standard protocol for children, and the protocol could be disseminated to other facilities and hence will lead to future reduction in radiation exposure to paediatric population.

1.5 RESEARCH QUESTIONS

1. Are the CT scanning parameters adjusted according to age and weight for safe pediatric patient's examinations?

2. What are the radiation doses for CT examinations in paediatric patients at MNH?

3. Are the radiation doses comparable to established doses for age and/or weight?

1.6 OBJECTIVES

1.6.1 Broad objective

To determinecomputed tomography scanning parameters in pediatric patients at Muhimbili National Hospital.

1.6.2 Specific objectives

1. To determine sociodemographic factors among pediatric patients undergoing computed tomography examination at MNH from September 2017 to March 2018.
2. To determine the indications of Computed Tomography imaging in pediatric patients at MNH from September 2017 to March 2018.
3. To determine the values of CT scanning parameters including tube current, kilo voltage, collimation and pitch among paediatric patients at MNH from September 2017 to March 2018.
4. To determine the computed tomography radiation doses at different body regions (head, chest and abdomen) among paediatric patients at MNH and to relate these to recommended doses per age and/or weight from March 2017 to September 2018.

2. METHODOLOGY

2.1 Type of study

The study was a cross sectional hospital based study.

2.2 Study duration

The study was conducted from September 2017 to March, 2018.

2.3 Study area

The study was conducted at Radiology Department of Muhimbili National Hospital. MNH is the National referral and teaching government hospital in Tanzania, located in Dar es Salaam Region. It receives referrals from all hospitals over the country.

2.4 Study population

Children referred to Radiology Department for computed tomography procedures.

2.5 Inclusion criteria

Children aged from 0 years to 15 years undergoing head, chest or abdominal CT with a request form from qualified medical practitioner.

2.6 Exclusion criteria

1. Very sick children on life support machines.
2. Those without request form from qualified medical practitioner.
3. Children with two combined CT examination example chest and abdomen
4. Refusal to sign consent form.

2.7 Patients involved

All children who will fulfill inclusion criteria.

2.8 Sampling method

Convenience sampling technique was used; All eligible children seen from June to December, 2017 were included until the sample size was reached**.**

2.9 Sample size

The sample size calculated from Fishers formula

$n=Z^2P\ (1-P)/E^2$

Where: n= sample size,

Z = (1.96)

P = prevalence = 13%. **(From the study conducted by Professor Muhogora et al in 2010)**

95% confidence interval will be used.

E = margin error 5%

Therefore $n= (1.96)^2 \times 0.13\ (1 - 0.13)/ (0.05)^2 = 174$

Thus the sample size in this study is 174 children

2.10 Collection of data

Data collection was done through structured questionnaire which were filled by principal investigator. Data collected included socio-demographics, indications of particular CT examination, scan parameters i.e. kVp, mAs, pitch, slice thickness, number of slices, scan length, field of view (FOV), total scan time, rotation time, displayed CTDIvol and displayed DLP.

Study variables

For assessment of CT dose the following scanning parameters were studied.

Tube potential (kVp), tube current (mAs), Pitch, number of slices, slice thickness, scan length, total scan time, rotation time, table feed per rotation, displayed CTDIvol and displayed DLP.

2.11 CT Dose calculation

CT dose index is considered as dose descriptor in CT. CTDI is machine inbuilt and isdisplayed in CT scanner console, but this does not represent the actual absorbed or effective dose for the patient. Radiation dose estimation was therefore determined using the calculatedVolume CT dose index (CTDIvol) in mGy the dose- length product (DLP) in mGy and CTDIw. TheCTDOSE computer software supplied by Imaging Performance and Assessment of CT scanners (ImPACT) was used to obtain the calculated dose for comparison with those from scanner console and Kvp, mAs, pitch, slice thickness, start and end positions of each scan was used as input data.

2.12 Data analysis

Data analysis was done using the Statistical Package for Social Sciences (SPSS).Data analysis examined relationship between different variables and CT dose.The outcome was the CT doses and the baseline independent variables included age, gender, and scanning parameters that may influence radiation doses such as kVp, mA, pitch and slice thickness.

The CT scanning parameters for different parts of the body such as head, chest and abdomen were compared with the international proposed values together with their associated doses. The mean values for CT dose descriptors i.e. Mean CTDI, and DLP were compared with the international Diagnostic reference levels.

2.13 Ethical consideration

The Researcher introduced herself to the parent or guardian of a child and gave the explanation of the study then requested the parent/guardian to allow the child to participate in the study and consent was obtained from the parent/guardian. For older children more than 10 years consent was obtained from the child as well. Child's weight and height measurements were taken, and no Interview was conducted. The patients' information's is confidential. Data was handled confidentially and stored in a secured place.

2.14 Ethical clearance

The proposal was presented to the department of Radiology, Muhimbili University of Health and Allied Sciences. Ethical clearance was thereafter be obtained from the Research and Publication Committee of the Muhimbili University of Health and Allied Sciences.

2.15. Study limitation and mitigation

The children are usually restless during imaging and therefore sedation was required in younger children.

CHAPTER THREE

3.0 RESULTS

3.1 Demographic findings

A total of 174 patients were participated in this study, of which 95(54.6%) were male and 79(45.4%) female as shown in the Table 1 below. The patients' mean age was 6.3(±4.7) years old. Age ranged from 0.01-15 years old. Majority of the patients were age group of 1-5 years old 55(31.6 %%) as Table 1 below shows.

Table 1: Sociodemographic factors among paediatric patients undergoing CT examination at MNH.N=174

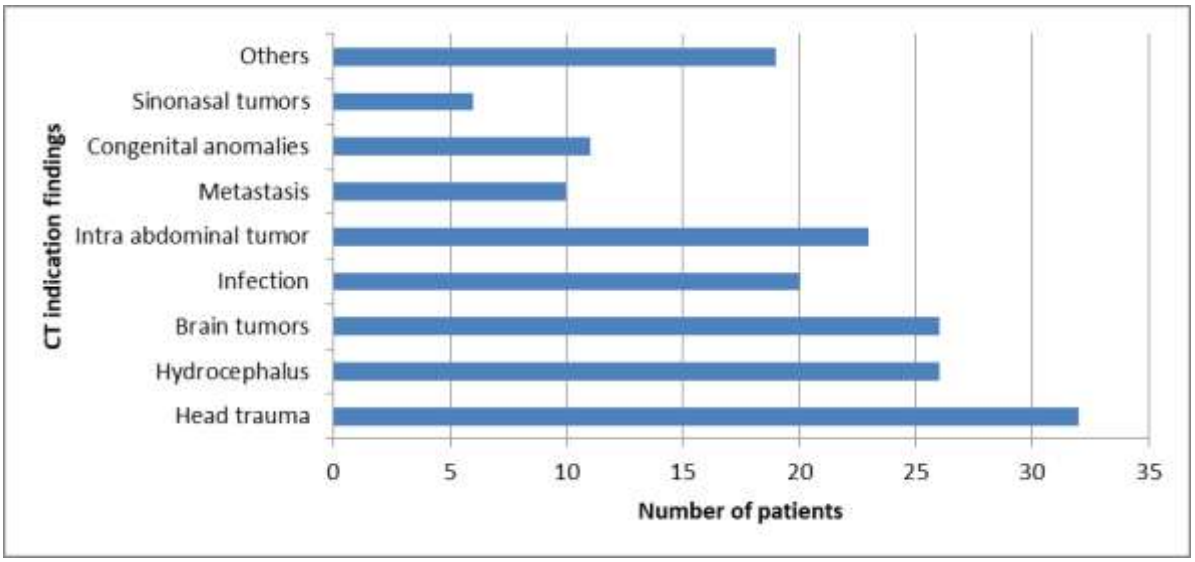
Demographic characteristics		Sex		
		Male	**Female**	**Total**
Age group	<1	18 (58.1%)	13 (41.9%)	31 (100%)
	1-5	31 (56.4%)	24 (43.6%)	55 (100%)
	6-10	26 (59.1%)	18 (40.9%)	44 (100%)
	11-15	20 (45.5%)	24 (54.5%)	44 (100%)
	Total	**95 (54.6%)**	**79 (45.4%)**	**174 (100%)**

Table 2: Social demographic factors and type of examination in children undergoing CT examination at MNH.N=174

Demographic characteristics		Type of examination			
		Abdominal CT	**Head CT**	**Chest CT**	**Total**
Sex	Male	25 (26.3%)	68 (71.6%)	2 (2.1%)	95 (100%)
	Female	20 (25.3%)	44 (55.7%)	15 (19.0%)	79 (100%)
	Total	**45 (25.9%)**	**112 (64.4%)**	**17 (9.8%)**	**174 (100%)**
Age group	<1	6 (19.4%)	23 (74.2%)	2 (6.5%)	31 (100%)
	1-5	18 (32.7%)	31 (56.4%)	6 (10.9%)	55 (100%)
	6-10	6 (13.6%)	36 (81.8%)	2 (4.5%)	44 (100%)
	11-15	15 (34.1%)	22 (50.0%)	7 (15.9%)	44 (100%)
	Total	**45 (25.9%)**	**112 (64.4%)**	**17 (9.8%)**	**174 (100%)**

The number of head CT examinations were higher in both male 68(71.6%) and in female 44(55.7%) followed by abdominal CT examinations where male were 25(26.3%) and female 20(25.3%) as shown in the Table 2 above. The table 2 above also shows that the proportion of head CT examination was higher for all age groups.

Figure 1: Distribution of the indications of Computed Tomography imaging in pediatric patients at MNH. N= 174



The results shown that head trauma was the most common indication found, followed by hydrocephalus and brain tumors; the third was intra-abdominal tumor as depicted in the Figure 1 above, Sino nasal tumors were the least prominent indications found. Others includeLymphoma, retinoblastoma, intestinal obstruction, chest masses, and osteosarcoma of the hip and parotid tumors.

Table 3: Values of CT scanning parameters in paediatric patients at MNH N=174

Type of examination	Abdominal CT (N=45)		Head CT (N=112)		Chest CT (N=17)	
	Mean ± SD	Range (Min-Max)	Mean ± SD	Range (Min-Max)	Mean ± SD	Range (Min-Max)
Tube Potential	83.6±7.7	80-100	115.9±9	80-120	91.8±10.1	80-100
Tube current	130.8±41	45-245	209±34.5	76-325	89.1±30.4	52-144
Effective mAs	109.5±68.3	18.5-345	164.3±55.1	61-350	105.1±58.3	56-255
Pitch	1±0.4	0.6-1.5	1.6±1.3	0.5-15	1.2±0.0	1.2-1.2
Slice Thickness	4.9±4.1	0.75-10	3.3±1.6	0.5-10	9.4±1.7	5-10
Total Scan Time	6.7±2.6	2.65-11.5	2.7±0.8	0.5-5.19	3.1±0.7	2.23-4.16
Rotation Time	0.5±0	0.5-0.5	0.5±0.1	0.28-1	0.5±0.1	0.28-0.5

Most of paediatric CT examinations were performed at tube potential ranging from (80-120)kVp for the head, and(80-100)kVp for the chest and abdomen.Tube current range of(76-32)mAs for head and (52-14)mAs (4,45-245)mAs for chest and abdomen respectively. Pitch ranged from (0.6-1.5)mm for all examinations. Slice thickness ranged from of (0.5-10)mm for head,(5-10)mm for chest and(0.75-10)mm for the abdomen. These ranges are within the recommended

values, except for the slice thickness of which the range exceeds 5mm which is not recommended for paediatric examinations.

Table 4: Values of CT scanning parameters by weight group in paediatric patients at MNH. N=174

	Weight	N	Tube Potential Mean (Range)	Tube current Mean (Range)	Pitch Mean (Range)	Slice Thickness Mean (Range)
Head CT	<10	18	111.1(100-120)	203.2(150-325)	1.3(0.5-1.5)	3(2-5)
	10-15	31	116.1(100-120)	197.9(107-244)	1.4(0.8-1.5)	3.2(0.6-5)
	15-30	48	117.1(80-120)	214.2(76-320)	1.7(0.5-15)	3.4(2-10)
	30-45	15	117.3(100-120	222.5192-298)	1.5(1.5-1.5)	3.3(0.5-5)
Chest CT	<10	3	86.7(80-100)	113.3(52-144)	1.2(1.2-1.2)	10(10-10)
	10-15	4	85(80-100)	95(52-130)	1.2(1.2-1.2)	10(10-10)
	15-30	4	90(80-100)	72.5(60-86)	1.2(1.2-1.2)	7.5(5-10)
	30-45	6	100(100-100)	84.2(66-93)	1.2(1.2-1.2)	10(10-10)
Abdominal CT	<10	5	84(80-100)	89.2(45-125)	0.8(0.6-1.2)	6.3(0.75-10)
	10-15	11	83.7(80-100)	116(80-167)	1.20.6-1.5)	3(0.75-10)
	15-30	22	81.8(80-100)	137.3(78-215)	1.0(0.6-1.5)	4.6(0.75-10)
	30-45	7	88.6(80-100)	163.7(85-245)	0.6(0.6-1)	8(0.75-10)

The mean values of tube potential, tube current and pitch for the head were more than for the chest and abdomen and these increased with weight as demonstrated in Table 4.The mean values of slice thickness for the head were relatively lower while those for chest were higher than for abdomen.

Table 5: Values of CT scanning parameters by age groups in paediatric patients at MNH.

	Age group	N	Tube Potential Mean (Range)	Tube current Mean (Range)	Pitch Mean (Range)	Slice Thickness Mean (Range)
Head CT	<1	23	111.3(100-120)	204.1(150-325)	1.4(0.5-1.5)	3.2(2-5)
	1-5	31	117.4(100-120)	199.6(107-244)	1.9(0.8-15)	3(0.6-5)
	6-10	36	117.8(80-120)	211.8(76-314)	1.5(1.5-15)	3.3(2-5)
	11-15	22	115.5(100-120	223(189-320)	1.5(1.5-1.5)	3.8(0.5-10)
Chest CT	<1	2	80(80-80)	144(144-144)	1.2(1.2-1.2)	10(10-10)
	1-5	6	86.7(80-100)	86.3(52-130)	1.2(1.2-1.2)	10(10-10)
	6-10	2	100(100-100)	72(72-72)	1.2(1.2-1.2)	5(5-5)
	11-15	7	97.1(80-100)	80.7(66-93)	1.2(1.2-1.2)	10(10-10)
Abdominal CT	<1	6	83.3(80-100)	97.3(45-138)	0.9(0.6-1.4)	5.8(0.75-10)
	1-5	18	82(80-100)	119.6(80-182)	1.1(0.6-15)	4(0.75-10)
	6-10	6	80(80-80)	146.3(107-175)	1.1(0.6-1.5)	2.7(0.75-10)
	11-15	15	86.7(80-100)	151.5(78-245)	0.9(0.6-1.5)	6.5(0.75-10)

The mean values of tube potential, tube current and pitch for the head were more than for the chest and abdomen. The tube potential increases with age, the tube current increases with age for head and abdominal examinations but decrease with age for chest examinations. The mean values of slice thickness for the head were relatively lower while those for chest were higher than for abdomen.

Table 6: Displayed CT radiation doses by age groups among pediatric patients at MNH.

	Age group	N	Displayed CTDIvolmGy Mean (Range)	Displayed DLPmGycm Mean (Range)
Head CT	<1	23	27.3(18.7-34.1)	582.8(44.8-893.8)
	1-5	31	29.3(0.3-37.3)	704.4(7.3-1121.2)
	6-10	36	31.4(3.3-39.7)	816.6(40.3-1204)
	11-15	22	66(3.7-789.6)	787.4(29.7-1269)
Chest CT	<1	2	2.8(2.8-2.8)	56.8(56.8-56.8)
	1-5	6	2.1(1.3-2.6)	32.6(58.2-99.1)
	6-10	2	3(3-3)	99.1(99.1-105)
	11-15	7	3.2(1.2-4)	105(33-131.8)
Abdominal CT	<1	6	1.8(0.7-2.7)	63.2(17-114)
	1-5	18	2.2(1.5-3.3)	87.7(36.8(164.7)
	6-10	6	2.8(1.8-3.4)	150.7(87.3-202.6)
	11-15	15	3.4(0.6-9)	153.6(15.9-424.8)

The mean values of CTDIvol and DLP for the head were more than for the chest and abdomen and these increased with age as demonstrated in table 6.

Table 7: Calculated Computed Tomography radiation doses by weight groups among pediatric patients at MNH.

	Weight group	N	Calculated CTDIvol Mean (Range)	Calculated DLP Mean (Range)	CTDIw
Head CT	<10	18	12.9(4.9-33.4)	252.4(83-767)	14.9(3.9-31.6)
	10-15	31	11.3(4.6-16.4)	220.8(107-393)	16.6(4.9-24.5)
	15-30	48	11.9(2.1-27.7)	235.3(57-567)	17.2(2.7-30.5)
	30-45	15	11.6(5.5-19.3)	224.9(103-376)	17.4(8.3-28.3)
Chest CT	<10	3	0.9(0.7-1)	35.7(28-41)	1.1(0.8-1.2)
	10-15	4	0.8(0.5-0.9)	31.3(24-37)	0.9(0.6-1)
	15-30	4	0.7(0.4-1)	27.8(20-44)	0.8(0.6-1.2)
	30-45	6	1.2(0.4-1)	46.3(33-56)	1.4(1.1-1.5)
Abdominal CT	<10	5	1.3(0.6-2.1)	68.2(26-106)	1.1(0.4-1.8)
	10-15	11	1.2(0.5-3.7)	36-89)	1.4(0.7-2.3)
	15-30	22	1.7(0.5-3.7)	81.9(24-171)	1.6(0.7-3.5)
	30-45	7	3.4(2.1-6.7)	158.1934-316)	2(0.7-3.5

The calculated CT doses for head and chest were higher in body weight less than 10kg compared to other weight groups. For abdominal examinations, the doses increased with weight. The CT doses were relatively higher for the head compared to chest and abdomen.

Table 8: Calculated Computed Tomography radiation doses by age groups among pediatric patients at MNH. N=174

	Age group	N	Calculated CTDIvol Mean (Range)	Calculated DLP Mean (Range)	CTDIw Mean (Range)
Head CT	<1	23	12.5(4.9-33.4)	246(83-767)	15.4(3.9-31.6)
	1-5	31	11.5(4.6-15.2)	219.6(107-312)	17.1(4.9-22.7)
	6-10	36	12.2(3.3-27.7)	248(57-567)	17.5(2.7-30.5)
	11-15	22	10.9(2.1-19.3)	212.1(93-376)	16.4(3.1-28.3)
Chest CT	<1	2	1(1-1)	39.5(38-41)	1.2(1.2-1.2)
	1-5	6	0.7(0.5-0.9)	29.3(23-37)	0.8(0.6-1)
	6-10	2	0.8(0.6-1)	34(24-44)	1(0.6-1)
	11-15	7	1(0.6-1)	42.6(20-56)	1.3(0.7-1.2)
Abdominal CT	<1	6	1.3(0.6-10)	64(26-106)	1.1(0.4-1.3)
	1-5	18	1.3(05-2.4)	65.2(24-126)	1.3(0.7-1.8)
	6-10	6	1.8(1-2.9)	90(44-147)	1.8(1.1-2.3)
	11-15	15	2.6(0.8-6.7)	119.8(41-316)	1.9(1.2-4)

The calculated CT doses for head were higher in age group less than 1 year compared to other age groups, however the doses increase with age for abdominal examinations,The mean values of CTDIvol, DLP, and CTDIw for the head were significantly higher than for the chest and abdomenas demonstrated in Table above.

Table 9: Calculated CT dosimetry values compared with displayed dosimetry values

Values	Displayed CTDI volmGy	Calculated CTDIvol mGy	Displayed DLPmGy.cm	Calculated DLPmGy.cm
Head CT	36.7816	11.8196	731.798	232.6518
Chest CT	2.7218	0.8941	78.6118	36.5294
Abdominal CT	2.6082	1.7978	114.8089	86.5556
TOTAL	42.1116	14.5115	925.2187	355.7368
P value at 95%CI	**0.001**	**0.0001**	**0.0001**	**0.0001**

The calculated CTDIvol were significantly lowerthan the values displayed on the scanner console (p - value = 0.0001, 95%CI). The calculated DLP were significantly lower than the values displayed on the scanner console (p – value = 0.0001, 95%CI)

Table 10: Mean CTDIvol by age compared with data reported from other international values

Types of examination	CTDIvol	This study		Australia		European	
	Age group (years)	CTDIvol	DLP	CTDIvol	DLP	CTDIvol	DLP
Head CT	<1	12.5	246	10.5	100	25	300
	1-5	11.5	219.6	10.5	100	38	505
	6-10	12.2	248	12	120	53	700
	11-15	10.9	212.1	15	150	60	900
Chest CT	<1	1.0	39.5	1.5	25	3.3	45
	1-5	0.7	29.3	1.5	55	5.6	115
	6-10	0.8	34	2.0	100	5.7	180
	11-15	1.0	42.6	2.5	150	6.9	200
Abdominal CT	<1	1.3	64	1.5	25	5.7	160
	1-5	1.3	65.2	1.5	55	5.7	170
	6-10	1.8	90	2.0	100	7.0	290
	11-15	2.6	119.8	2.5	200	14	580

Table 10 illustrate that the doses from this study i.e. mean CTDIvol and DLP for the head were higher compared to Australian values but relatively lower compared to values reported by European study. This shows us that there is a great need to reduce the doses for head examination by adjusting the scanning parameters. For the chest and abdominal examinations, the mean CTDIvol and DLP from this study were relatively lower compared to those of Australia and Europe.

Table 11: Comparison of the mean values of CTDIvol for head and Chest CT with minimum CTDIvol reported from IAEA

Types of examination	CTDIvol		
	Age group (years)	This study	IAEA
Head CT	<1	12.5	2.3
	1-5	11.5	2.7
	6-10	12.2	5.0
	11-15	10.9	14.5
Chest CT	<1	1.0	0.4
	1-5	0.7	0.5
	6-10	0.8	0.5
	11-15	1.0	0.5

The mean CTDIvol for head and chest were relatively higher compaired with the minimum CTDIvol reported to International Atomic Energy Agency.Although these findings lack abdominal values but still can make us learn that we can still have much lower doses than those we are using to scan our children. These values tells us that despite of the use of low radiation doses compaired to many other international values, it is possible to further reduce our doses to as low as those reported to IAEA.

CHAPTER FOUR

1.0 DISCUSION

The study involved a total of 174 patients from age 0 to 15years. The majority of paediatric CT scan examinations were performed on children of 1-5 years (31.6%) Similarly, a study done in Switzerland by Francis R.et al, showed that most children underwent CT examinations were younger than 5 years of age(27). However a study by Kisembo et al noted the highest frequency of CT scan examinations to be in the age group 10-14(10). The lack of awareness about the hazards of CT radiations in children can also be the reason for the high number of CT scan examinations performed on the very young children as noted in this study.

Males had higher number of CT examination compared to females in this study (62.9%). Similar findings were noted in a study by Nasoor etal (28) and a study done in Uganda(10)

Head CT were the commonest examination performed (64.4%) than chest and abdomen. Similar findings were noted in astudy done by Brady et al(29) and Buls et al(30). This is caused by more number of head injury found in this study which warrants CT scans. Ultrasound and plain radiograph are still the main stay modalities of choice for abdominal and chest imaging for paediatrics respectively.

With regard to CT scanning parameters, the mean values of tube potential, tube current and pitch for the head were more than for the chest and abdomen.Similar findings were noted by a study done in Portugal (30) and in Australia (31). The mean tube potential and tube current for the head were 115.4kVp and 209.45mA respectively with no evidence of adjustment based on body size and age of the patient. The mean tube potential and tube current for chest and abdomen were adjusted for paediatric body size and age with the mean value of 84.52 kVp and 90.42kVp for the tube potential and 126.5mA and 91.25mA for tube current respectively. Most of abdominal and chest examination were conducted using slice thickness of 10mm, this is very large for children due to their small body sizes. The slice thickness of 5mm is recommended by WHO for paediatric examinations(3).

The doses for Head CT examinations were higher compared to the chest and abdomen, CTDIvol (mGy) 11.78, DLP(mGy.cm) 231.42 and CTDIw (mGy) 16.6, similar findings were noted by(31)(27) and(32). This is due to the use of adult scanning parameters such as 120 kVp for head examinations. We therefore need to adjust the parameters for head examinations inorder to minimize the radiation dose inflicted to our children. The calculated CT doses for head were

higher in age group less than 1 year and weight group less than 10 kg compared to other age groups. This shows that the doses are not adjusted according to age and weight and therefore we really need to adjust them accordingly. There is also a great need to adjust our scanning parameters in order to further reduce the radiation doses to the very young ones. The principles of radiation protection in paediatrics require use of less radiation doses to younger age group.

The mean CTDIvol and DLP for the head were higher compared to Australian values(33) but relatively lower compared values reported by other international values(31)(27)(32)study. Although these presented data were lower than the values presented by most literature,more lower values were reported by International Atomic Energy Agency(32). This tells us that we can further reduce our doses to the lowest levels like those reported from IAEA or more lower than that if we use recommended scan parameters for children. As the Afrosafecampaign insist on promotion of radiation safety in radiological facilities CT examination should be kept safe for paediatric imaging **(33).**For the chest and abdominal examinations, the mean CTDIvol and DLP from this study were relatively lower(3.4)mGy. An (153)Mg.cm respectively, compared to those reported from other countries(32)(31), this is caused by the use of large slice thickness(10mm) and the use of low tube current. Although some pathology can be missed because of the use of larger slice thickness in children's small bodies, multi planar multi slice reconstruction technique can provide that information.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion.

The patients involved in this study had the age range of 0 -15years, and the majority was male. Head trauma was the most common indication encountered; most of the indications were justifiable though some few lack justification. Scanning parameters for head CT examinations are not adjusted for paediatric examinations. The use of large tube potential and tube current for head examinations has led to large doses for head examinations. The radiation dose mean values for CTDI vol, and DLP were significantly lower than those from other countries, however lowest doses have been reported to IAEA. We therefore still have the chance to further reduce our doses to the lower levels than these so as to reduce the level of radiation to our children.

Recommendations

1. The use of recommended scanning parameters for head CT examination such as low tube potential (kVp) and low tube current in paediatric imaging should be adhered.
2. Further CT dose reduction is needed despite the fact that our doses are lower compared to many other international values. This is because we need to minimize the radiation dose to children to as low as reasonably achievable. .
3. Further studies with larger sample size should be conducted all over the country involving different CT centers, using this study as a base line to develop Diagnostic reference levels for paediatric CT examinations

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