THE ROLE OF COMPUTERIZED TOMOGRAPHY IN THE DIAGNOSIS OF INTRACRANIAL PATHOLOGY IN CHILDREN AT KENYATTA NATIONAL HOSPITAL

A Dissertation submitted in part-fulfillment for a Masters Degree in Diagnostic Imaging and Radiation Medicine of the University of Nairobi.

By

Dr. Cyprian Agumba Odeny M.B.Ch.B (NBI)

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DECLARATION

I declare that this dissertation is my original work and has not been presented for a degree in any other university.

Author:

Dr. Cyprian Agumba Odeny

H58/70481/07

SIGN__________________DATE_____________

Supervisor

This dissertation has been submitted for examination with my approval as the university supervisor.

Dr GLADYS N. MWANGO

BSc(Anatomy) M.B.Ch.B, MMED (NBI)

Consultant Radiologist & Lecturer

Department of Diagnostic Imaging and Radiation Medicine,

University of Nairobi.

SIGN__________________DATE_________________

DEDICATION

This book is dedicated to my late dad Hendricus and late mum Gaudencia for their wise investment in my upbringing and education.

Special appreciation goes to my wife Millie and dear children Sharon, Nicole and Andrew for their steadfast moral support and encouragement.

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ABBREVIATIONS AND ACRONYMS

ALARA: As Low As Reasonably Achievable

CT: Computed Tomography

CXR: Chest radiograph

CXRs: Chest radiographs

E.d: Effective dose

ICRP : International Commitee on Radiation Protection

KNH : Kenyatta National Hospital

kV: Kilovoltage

Lat: Lateral

mAs: Milliampere seconds

mGy: Milligray

mSv: MilliSieverts

MDCT : Multi Detector Computerized Tomography

MRI: Magnetic Resonance Imaging

RTA : Road traffic accident

SPSS: Statistical Package for Social Sciences

UK : United Kingdom

USA : United States of America

DEFINITION OF TERMS

Computed Tomography: This is a noninvasive imaging method that combines x-rays with computer technology. X-ray beams from many angles are used to create a series of detailed cross sectional images.

Magnetic Resonance Imaging (MRI) : Imaging method employing the use of powerful magnets to acquire images of the body in multiple planes.

ULTRASONOGRAPHY : Method of imaging employing the use of high-frequency sound waves to acquire images of the body.

ETHICAL CONSIDERATIONS

The research proposal was first reviewed at the departmental level. It was then submitted to the UON/KNH ethics and research committee which granted ethical approval after thorough scrutiny.

During the study measures aimed at further reduction of radiation dose were reinforced. There were no additional costs to the patients as a result of this study. The study findings will be disseminated for publication.

ABSTRACT

INTRODUCTION

The rapidly growing use of CT scan in paediatrics worldwide carries the potential for increased radiation exposure to children undergoing these scans. This has been associated with small but significant increased risk of carcinogenesis.(1) Large studies have detected this small risk, which appears to be related to the cumulative radiation dose of all previous exposures in a linear fashion.(2).The consensus among paediatric radiologists is that about 30% of paediatric CT examinations are unnecessary.(3) CT head is by far the most commonly performed CT examination among children aged five years and below at KNH.(4)

OBJECTIVE

The main objective of the study was to determine the role of CT in diagnosis of intracranial pathology in children aged five years and below at KNH. The other objectives were to establish the patient screening practice and to document radiation dose minimization measures practiced at KNH during cranial CT exams on young children. However it was not designed to measure actual absorbed radiation doses.

METHODOLOGY

This was a prospective cross-sectional study conducted at the Kenyatta National Hospital (Nairobi) which is the main teaching and referral hospital in Kenya. It spanned the six month period from January 2010 to June 2010. The study was performed on a 16 slice multi-detector CT scanner, Brilliance model, serial no.729 manufactured by Phillips in January 2007. Data collection was done in the KNH CT scan room, using a well structured data sheet. Data analysis was done by computer using Software Program for Social Science research (SPSS-Pc version 11.0).

RESULTS

A total of 101 patients were studied. The study group included 65(64.4%) males and 36(35.6%) females. The age distribution ranged from 1- 60 months. 50(49.5%) were inpatients while 51(50.5%) were outpatients.

Only 45% of the cranial CT request forms for patients included in this study were found to have been vetted and signed by a radiologist.

The most common indication for cranial CT was convulsions followed by head injury. Convulsions as a cranial CT indication was found to be most common in the under 12 month age group.

The most common CT diagnosis was infections and infestations (25.7%) followed by normal scan (17.8%).

Only 6.0% of inpatient referrals had normal scans compared to 29.4% normal scans among outpatient referrals. This could be due to a more effective patient screening system in the inpatient departments. Furthermore inpatients are also likely to have more severe signs and symptoms which would be associated with radiologic signs.

Views on the accuracy of the provisional diagnosis given by the referring clinician from the inpatient and outpatient departments are discussed.

Although paediatric cranial CT exams at KNH are done according to established routine standard operating procedures(SOPs), this study revealed the lack of a written outline of these SOPs in the radiology department. Subsequently the principal researcher contributed to the development of written SOPs in collaboration with radiologists at the CT section. The study also found that thyroid shielding is not routinely applied during paediatric cranial CT exams at KNH due to shortage of thyroid shields.

CONCLUSION

CT was found to be a useful and adequate diagnostic tool for intracranial pathology in young children. However it is important for healthcare community to work together to minimize radiation dose to children.

Hopefully recommendations based on the findings of this study will help to emphasize to clinicians, technicians and radiologists the need to adopt best practices and techniques aimed towards radiation dose minimization during paediatric cranial CT exams and ensuring that only appropriate or relevant examinations are performed.

INTRODUCTION

The first CT scanner was developed in 1972 by Sir Godfrey Hounsfield in the U.K.(5). Since then CT as a radiological technique has found application in a wide range of clinical situations.

With technological advancement CT has rapidly evolved over the years through a series called generations of CT scanners. Technological advancements have mainly been aimed at shortening image acquisition time. To date, state of the art CT systems have upto 64 rows of detectors allowing upto 4 centimeters to be imaged per revolution, a revolution time of 0.4 seconds, with a resolution of approximately 0.4 millimeters.(6)

The scanner used in this study is a Phillips Brilliance 16, a 16 slice scanner which contains 16 rows of detectors and allows for upto 2 centimeters to be imaged per revolution.

CT uses x-rays to generate two dimensional images of a body section. The images are acquired by rapid rotation of the x-ray tube 360 degrees round the patient. The transmitted radiation is then measured by a ring of sensitive radiation detectors located on the gantry round the patient.

The final image is generated from these measurements using basic principles that the internal structure of the body can be reconstructed from multiple x-ray projections. Images can be reconstructed in multiple planes to give three dimensional images.

CT was one of the first non-invasive imaging techniques for 3-dimensional visualization of neuro-anatomic structure. Before CT the main modes of imaging cerebral structure, ventriculography and pneumoencephalography, relied on plain film technology and were quite invasive. The advent of CT ushered in a new era of neuroimaging. CT provided a tool to create reliable and accurate representations of internal structure using non invasive techniques, and as a result fostered an acceleration in the growth of neurosciences. Despite the development of other imaging techniques such as MRI, CT continues to play an important role in neuroimaging.(7)

CT offers distinct advantages over other imaging modalities e.g. excellent image quality, rapid acquisition time, at relatively low cost and it is widely available. In many clinical situations CT remains the diagnostic study of choice.(7)

In the emergency setting CT is the preferred study for evaluating abrupt change in mental status or head injury or for ruling out acute intracranial hemorrhage.
Owing to long image acquisition times as well as cost and availability considerations, MRI may be ordered as follow-up scans after CT results have been obtained and medical stability is assured.(7)

One significant benefit of CT which has been established by researchers is a decrease in hospital charges and bed occupancy by shortening the time for diagnostic studies.(8,9)

This study focused on children aged five years and below because they are the most vulnerable to the harmful effects of the relatively high levels of ionizing radiation which is inevitably associated with CT examinations. Rational use of CT cannot be overemphasized for this age group.

The study was preferrably conducted at KNH because it is the premier teaching and referral hospital in Kenya. Findings of this study are therefore expected to give a representative spectrum for the whole country and can be easily disseminated to the country's medical fraternity.

LITERATURE REVIEW

CT is extremely valuable, and can be a life saving tool for diagnosing illness and injury in children. For an individual child, the risks of CT are small and the individual risk-benefit balance favours the benefit when used appropriately. (10)

While Ultrasound is the preferred imaging modality for intracranial pathology in infants, CT and MRI are necessary in older children, after the closure of fontanelles.

Cranial CT is useful in the diagnosis of a wide range of intracranial pathology including:- Congenital lesions, hydrocephalus, neoplasms, cysts, intracerebral hematomas, subarachnoid hemorrhage, aneurysms and infarcts. (10)

Because of the clear distinction between high attenuation of extravasated blood and that of the surrounding brain, CT scanning is by far the most accurate radiological method for demonstrating intracerebral hematoma. CT is also the most important primary investigation in subarachnoid hemorrhage. (10)

CT is of value in diagnosis of lesions due to acute head trauma such as extradural and subdural hematomas, intra-cerebral hematomas, cerebral contusion, skull fracture and foreign bodies. In the management of both extra-dural and subdural hematomas, CT permits the detection of residual or recurrent lesions, of undiagnosed contralateral hematomas, or the presence of infection. Basal skull fractures, which are often difficult to demonstrate by plain radiography, are shown very clearly by CT. (6,10)

Cranial CT, usually enhanced with intravenous contrast agents is of value in lesions caused by infections and infestations such as abcess, meningitis, empyema, toxoplasmosis, encephalitis, cysticercosis, and hydatid cysts. (10)

In paediatric neuroimaging CT offers several distinct advantages over other imaging modalities.

Besides being painless and noninvasive it has good sensitivity to detect most cranial disorders in a child and is far superior to MRI when evaluating skull fractures.

Owing to fast image acquisition capability it can rapidly identify most congenital disorders. It is therefore excellent for imaging restless children and head trauma patients. Motion artifacts are less of a problem in CT compared to MRI. Short- acting sedatives may be reliably used in a CT examination for restless patients.

CT can be performed in patients with implanted medical devices and it also provides dynamic imaging, and thus allows for needle biopsies to be performed simultaneously. It is also cheaper and more widely available than MRI.(6,7,10)

CT angiography is a three-dimensional technique that provides information about the imaged vessels and adjacent structures. It requires only venous vascular access and is an outpatient examination with minimal risk.(11). Helical CT Cerebrovascular imaging is an effective technique for assessing the intracranial circulation in children.(12,13). The use of CT angiography offers the opportunity to eliminate the long periods of sedation associated with MR and reduce the radiation exposure associated with conventional angiography. Generally, the benefits of CT angiography in children outweigh the risk, namely that of radiation exposure. However, care must still be taken to minimize the radiation exposure.(14).

To-date there are very few requests for cerebral CT angiography in young children at KNH. Records indicate that no cerebral CT angiography exams have been performed at KNH among children aged five years and below since the installation of the current multi-slice CT scanner two years ago.

One major disadvantage of CT scanning in children is the inevitable ionizing radiation associated with it. Radiation doses from CT scans of chest (3 mSv), head (4 mSv), and abdomen (5 mSv) correlate to 150, 200, and 250 chest x-rays, respectively(1). Repeated CT exams should therefore be minimized in children.

Iodine based contrast dye which is sometimes used in CT exams can cause allergic reactions and renal failure in individuals with diabetes or renal disease. Furthermore when compared to MRI , CT is not good at identifying soft tissue pathology and brain inflammation or infection.(6,7,10)

Several authors have reviewed CT head with regard to various causes :-

Strehlau (15) from her study done at MP Shah and Aga Khan hospitals in Nairobi, reported that primary brain tumours were the commonest intracranial lesions observed and accounted for 87%. The next common intracranial lesion was hemorrhage following trauma. Hydrocephalus was found in 19%. This study included both adults and children.

DeSousa (16) found that head injury was a common problem in Kenya and that CT scanning was a useful modality for evaluation of the problem. RTA accounted for the majority of trauma (52.5%) followed by assault (28.1%) and falls (10.6%). Intracranial hemorrhages, contusion injuries, and general brain oedema were frequent findings in this study. Significant intracranial pathology was often associated with absence of skull vault fractures and this emphasizes the superiority CT over plain films.

A study done by Probst (17) on brain deformities, hydrocephalus and atrophic conditions showed that CT provides information that cannot be obtained by most of the other neuroradiologic methods, apart from MRI.

Mashuke (18) analysed indications for CT examination at KNH in a study involving patients of all ages (4 months to 90 years). He found that the indication for majority of the patients referred for CT head was raised intracranial pressure due to space occupying lesion (25.5%). This was followed by traumatic brain lesion (15.2%). The commonest presenting signs/symptoms in children were convulsions, fever and hemiparesis. The accuracy of provisional diagnosis given by the referring clinician from the wards or outpatient clinics showed that, of all those referred from outpatient 51.9% had false provisional diagnosis compared to only 11.4% from inpatient. This was highly statistically significant ($z=6.3$, $p<0.001$). This underscores the need for thorough preliminary clinical assessment of young children before being subjected to cranial CT examinations.

CT has developed exceedingly rapidly in recent years. The majority of machines in use are now multidetector systems (MDCT) acquiring upto 64 slices in a single rotation. MDCT allows the user to acquire larger volumes, and thinner slices in the same time, both of which result in increased patient doses. (6)

In the U.S.A the use of CT in both children and adults has increased about 8 fold since 1980, with annual growth estimated at about 10% per year.(19). Despite the many benefits of CT, a disadvantage is the inevitable radiation exposure. CT is the largest contributor to medical radiation exposure in the U.S. population.(19). A recent comprehensive survey in the U.K. showed that CT scans constituted 7% of all radiological exams, but contributed 47% of the total collective radiation from medical x-ray exams in 2000/2001.(20)

Since 1997 CT has been designated a high dose procedure by the European Union. This calls for careful consideration of risk- versus benefit for every patient before a CT exam.

The use of computed tomography (CT) in pediatric patients has increased as the number of medical applications of pediatric CT has increased. (21) Despite the obvious benefit that pediatric patients and their families derive from the diagnostic information that CT provides, the radiation dose used in CT for pediatric patients has recently come under scrutiny , and the radiobiologic consequences appear to be nontrivial. (2,22) The X-ray radiation associated with CT scanning has been associated with small but significant increased risk of carcinogenesis. Large studies have detected this small risk, which appears to be related to the cumulative radiation dose of all previous exposures in a linear fashion.(2)

Image quality (e.g, contrast-to-noise ratio [CNR]) in CT depends primarily on the detected x-ray fluence. Consequently, the technical factors used in pediatric CT can and should be reduced in comparison with adult technical factors because smaller patients attenuate fewer x-rays. Thus, equivalent image quality can be produced at lower dose levels.

Chan et al performed CT in children aged 1–12 years with several different milliampere second values, and, by using observer-based subjective image assessment, found that a 40% reduction in milliampere seconds could be used in pediatric cranial CT. (23). Cohen et al also studied CT dose in pediatric head CT and concluded that a 40% reduction was possible. (24)

As children are not small adults imaging evaluation needs to be adapted to their special features and diseases. The most important consideration when imaging children is to optimize and reduce unnecessary or unnecessarily high radiation exposure. Whenever possible, a radiation free imaging modality should be chosen. Ultrasound is considered the primary examination method for infants in many circumstances and often reveals sufficient information.

Every imaging study with ionizing radiation requires a justifying medical indication. Radiography, fluoroscopy and CT should be performed on optimized equipment using special paediatric protocols in order to achieve the lowest radiation exposure possible. (25)

The responsibility for reducing patient dose should be shouldered by all parties. The referring clinician should ensure that the radiologist is given full clinical information to ensure that CT is indeed the most appropriate test. The radiologist should ensure that each study is justified, that the imaging protocols are optimized to answer the clinical question and that the dose to the patient follows the As Low As Reasonably Achievable (ALARA) principle.

To optimize CT, it is essential that both the practitioner and operator have a good understanding of the new technology and in particular how multislice CT differs from single slice. For example, in most multidetector CT, increasing the pitch no longer results in a dose reduction as the reconstruction technique means that the mAs must be increased to compensate. Innovations in CT scanner design and operations have enabled dose reduction solutions that are effectively in- built.(26,27) :-

- Weight based, age based and other CT scan protocols are provided with new CT equipment. These help new users achieve optimum diagnostic results . They particularly optimize dose for infants and children.
- Automatic exposure control protocols instruct the imaging equipment to adjust current up and down depending on variations in patient attenuation, without relying on adjustments made by the imaging technologist.
- Use of Automatic bolus tracking technique in CT angiography avoids unnecessary duplications because of inadequate i.v. contrast enhancement. With this technique the amount of contrast needed to achieve the same contrast enhancement can be reduced.
- Enhancements in CT reconstruction improve image quality at all CT dose delivery levels by decreasing scatter and noise, hence improving image quality.
- Beam collimation limits dose delivery to coincide with the detector area of interest and scanning field of view.
- Beam filtration reduces low energy photons likely to be absorbed by the patient without contributing to image formation.
- Modern CT imaging equipment (like the model in use at KNH) provide access to dose data, generally by displaying the data on the console prior , during and post exam. This enables the operator to better understand the dose implications and protocol choices.

Table 1 : Effect of automatic tube current modulation on patient doses.(27)

Body region	Dose reduction
Skull	14 - 26%
Shoulder region	22 - 56%
Chest	19 - 27%
Abdomen	11 - 24%
Pelvis	21 - 30%
Extremities	33 - 41%

To get the best from these systems it is essential that they are set up appropriately in the first instance, which again requires a good understanding of both the imaging task and the technology. (28)

In the absence of standardized validated protocols, radiologists often obtain CT images using high radiation exposure levels to minimize image noise and maximize image quality. Studies in multiple jurisdictions have shown that the lack of standardization leads to wide variation in the level of radiation administered for the same CT examination between institutions, with no detectable difference in patient outcomes.(28,29) If CT parameters used for paediatric patients are not adjusted on the basis of examination type, age and/or size of the child, then some patients will be exposed to an unnecessarily high radiation dose during CT examinations.(30) In addition, studies have shown that radiologists, referring clinicians, and patients may be unaware of the high level of radiation exposure associated with CT examinations (31). This knowledge gap undoubtedly contributes to the overuse of CT in low-yield diagnostic situations and its overuse in following disease progression or treatment effects.

There are three unique considerations in children:-

-Children are considerably more sensitive to radiation than adults as demonstrated in epidemiological studies of exposed populations.

-Children also have a longer life expectancy than adults, resulting in a large window of opportunity for expressing radiation damage.

-Children receive a higher dose than necessary when adult CT settings are used for children.

As a result the risk of developing a radiation related cancer can be several times higher for a young child compared to an adult exposed to identical CT scan. CT settings can be reduced significantly while maintaining diagnostic image quality. Adjustments are frequently not made in CT exposure parameters that determine the amount of radiation children receive from CT, resulting in greater dose than necessary.(32)

Major international organizations responsible for evaluating radiation risks agree that no amount of radiation should be considered absolutely safe. Recent data from the Japanese Atomic bomb survivors and other irradiated populations demonstrate small, but significant increases in cancer risk even at the low levels of radiation that are relevant to paediatric CT examinations.(33,34)

Multiple CT scan examinations present a particular concern. Among children who have undergone CT scans in the USA, about one third have had at least three scans. In addition more than one phase may be done during a single examination.

It is important to stress that the individual cancer risks associated with CT scans are small, however, the Lifetime cancer mortality risk attributable to radiation exposure from a single head CT examination in a one year old child is 1:1500.(22)

Worldwide, the rapid increase in use of CT in paediatrics raises a public Health issue because an increasingly large paediatric population is being exposed to these small risks. (34)

Factors that may lead to increased radiation dose during paediatric cranial CT examination include:-

-Repeat examinations due to image errors caused by motion , hence sedation may be necessary for a restless child.

-Use of inappropriate CT protocols : Customised paediatric CT protocols should be used.

-Multi-phasic CT examinations: Post contrast exams should only be done when necessary.

Studies have established that repeated CT examinations of the same body region increases radiation dose in a linear fashion.

The following are some of the immediate measures in literature for minimizing CT radiation exposure in children:

i. Perform only necessary CT exams. This calls for communication between clinicians and radiologists to determine the need for the CT scan and the technique

ii Adjust exposure parameters for paediatric CT based on:

-Child's body size; guidelines based on individual size/weight parameters should be used.

- The region scanned should be limited to the smallest necessary area.

- The organ scanned: lower kV/mA settings should be considered for lung and skeletal structures and some CT angiographic and follow up exams.

- Studies have concluded that a 40% reduction in mAs is possible in paediatric CT head. (21,23)

- Minimize post contrast and multi-phase exams.

- Gantry tilt: During head CT scan the gantry should be angled cranially to avoid the orbits, in order to reduce radiation to the lens. In general few hospitals worldwide routinely practice this in children. Mwanyika (1995) found that no attempt was made to protect the eyes either in children or adults during cranial CT at Kenyatta National Hospital.(35)

Mwanyika also demonstrated in his study that absorbed doses to the eyes, frontal bone and parotid glands from CT scanning of the head are higher than the rest of the organs in the head. He also demonstrated that the more the slice numbers and, or the smaller the slice thickness the higher the mean radiation dose. Therefore selection of slice parameters and radiographic factors would assist in reducing radiation doses.

Table 2 : Effect of CT settings adjustment on the effective dose.(23)

Exam Type	Relevant organ	Range of absorbed organ doses. mGy	Range of E.d (mSv) #
CT Head unadjusted (200mAs)	Brain	23 - 49	1.8 - 3.8
CT Head adjusted (100 mAs)	Brain	11 - 25	0.9 - 1.9
CT Abdomen unadjusted (200 mAs)	Stomach	21 - 43	11 - 24
CT Abdomen adjusted(50mAs)	Stomach	5 - 11	3 - 6
CXR (PA)	Lung	0.04 – 0.08	0.01- 0.03
CXR (Lat)	Lung	0.04 – 0.10	0.03 – 0.06
Mammogram	Breast	3.5	0.42

: Stands for effective dose using the 2008 ICRP tissue weighting factors.

Effective dose is used in radiation protection to express detriment to the whole when only a part of the body is exposed. It takes into account the type of radiation and the sensitivity of the exposed organs or tissues. (Tissue weighting factor)

'Unadjusted' means using the .same CT settings as for adults.

Adjusted refers to settings adjusted for body weight.

Effective doses for chest radiograph and breast mammogram are given for comparison.

The figures on the table show how adjustment of CT settings for body weight drastically reduces the effective dose.

Radiation involved in brain scanning in young children may impair mental development according to a study done on more than 3000 subjects who received radiation therapy between 1930 and 1959 before they were 18 months old.(36)

The study, published in the British Medical Journal of January 2004, was conducted by researchers from Stockholm's Karolinska Institute and Harvard School of Public Health, who gathered and analyzed the subsequent school records of the subjects and compared them to those of their peers who had not had radiation therapy.(36)

They found a direct connection between the amount of radiation these infants were exposed to and the learning difficulties they suffered in later life.

The research team estimated that 1.5 million CT scans are carried out on children world wide every year often with radiation levels higher than those tested in their study.

Seizure disorders and head injury account for a large proportion of requests for cranial CT examinations done on young children at Kenyatta National Hospital. Many of the cranial CT scans done on these children could be unnecessary.

Various studies have shown that febrile seizures occur in 3 -5% of children aged five years and below. (37,38,39)

In Kenya, high fever in young children can commonly arise from varied causes such as malaria, bacterial and viral upper respiratory tract infections, pneumonia, acute otitis media, bacterial and viral gastroenteritis, dehydration, electrolyte imbalance and febrile reactions after vaccination. A significant proportion of young children at Kenyatta National Hospital emergency department probably present with febrile seizures due to the above underlying causes. Meningitis rarely presents as simple febrile convulsion, but complex seizures, prolonged illness or toxicity are all indications for lumbar puncture.

Several factors must be present for a seizure to be classified as a febrile seizure. The seizure must occur in association with a fever of 38 degrees C (100.4 F), the child should be between the ages of 6 months – 5 years, and there should not be a history of neurological disease or any CNS infection. These seizures can either be simple or complex. A simple febrile seizure is usually generalized, lasts 15 minutes or less, and occurs only once in 24 hours. A complex febrile seizure may have features of a focal seizure some time during the seizure, may last more than 15 minutes, and can have more than one seizure episode within 24 hours.

Simple febrile convulsion is a benign condition with excellent outcomes but its mismanagement does however subject patients to serious complications.(39)

Neuroimaging is not recommended by American Academy of Paedriatrics in routine evaluation of the child with a first episode of simple febrile convulsion. Cranial CT scan is usually normal in these cases. Cranial CT is also normal in most cases of purulent meningitis including those with subsequent herniation.(40,41,42). An accurate clinical history and recognition of the early systemic and neurological findings of bacterial meningitis will indicate a safe setting for performance of a diagnostic lumbar puncture with little likelihood of complicating herniation.(43,44)

Head trauma is one of the most common situations where cranial CT scans are used in children. In cases of severe head trauma with coma and obvious skull fractures, the need for rapid assessment to save lives makes CT a clear choice. Plain films do not show any detail of intracranial injury. MRI takes much too long and interferes with monitoring of an unstable patient.

The more controversial use of cranial CT scanning in children is for minor head trauma. Thousands of pediatric patients with minor head trauma are seen in emergency departments (EDs) in the United States every year. The vast majority of these children have no intracranial injury, but 1% to 2% will have life-threatening intracranial injuries. Most of these injuries are treated successfully if detected early and repaired by a neurosurgeon, whereas if left to worsen may result in permanent disability or death.

CT scans for head trauma interpreted by competent radiologists have proven extremely reliable for evaluating these cases. At least five studies have shown that a negative CT scan of the head has had zero false negatives—even with skull fracture in many cases. If the CT scan shows no intracranial injury, there is a miniscule chance of neurological deterioration. Because of this wonderful reassurance, most children with minor head trauma are scanned with CT when the technology is available.(45)

All children with head injury who have Glasgow coma scale less than 15 should undergo cranial CT. Also, all children with head injury with Glasgow coma scale 15 with a history of more than 30 seconds loss of consciousness, or clinical findings of amnesia, drowsiness, persistent vomitting, skull fractures or focal neurological deficits should also have a cranial CT.(46,47)

Asymptomatic children under two years of age who have had head injury and a scalp haematoma or are suspected to have received non accidental injury, should also undergo cranial CT. There should also be a low threshold for imaging head injured children who are known to have coagulopathy.(46,47,4). Clinicians should be well versed with these imaging guidelines.

Mashuke (1995) found that 51.9% of patients of all ages referred to Kenyatta National Hospital for cranial CT from out patient clinics had false provisional diagnosis while those referred from in patient had a false provisional diagnosis rate of only 11.4%.(18)

The rate of false provisional diagnosis could be probably higher among young children who undergo cranial CT at Kenyatta National Hospital. This underscores the need for thorough preliminary clinical assessment of young children before being referred for cranial CT exam. Request forms for paediatric CT should also contain the relevant clinical information.

Finally, the role of the radiologist in vetting requests for paediatric cranial CT in order to minimize unnecessary examinations remains of paramount importance. (49)

BROAD OBJECTIVE

The objective of this study was to determine the role of CT in diagnosis of intracranial pathology in children aged five years and below at KNH.

SPECIFIC OBJECTIVES

a. To determine the age and sex frequency of children aged five years and below who undergo cranial CT exams at KNH.
b. To determine the frequency of various diagnoses among children aged five years and below who undergo cranial CT exams at KNH.
c. To correlate the CT diagnosis with the available clinical information on the request forms.
d. To document special radiation dose - reduction measures practiced during paediatric cranial CT scanning at KNH.

PROBLEM STATEMENT

It is probable that a significant number of young children are being subjected to unnecessary, inappropriate or avoidable multiple CT examinations due to inadequate preliminary clinical assessment. An effective screening system is therefore necessary for children who are referred for CT head examinations in order to ensure that each study is justified. Imaging protocols need to be optimized to answer the clinical question. Radiation dose to the patient should follow ALARA principle.

JUSTIFICATION OF THE STUDY

CT scan is currently the leading imaging modality for intracranial pathology in both children and adults worldwide. This owes to its ability to detect, localize and characterize intracranial disease non-invasively. It is also fast, relatively affordable and available.(7)

The rapidly growing use of CT scan in paediatrics worldwide carries the potential for increased radiation exposure to children undergoing these scans. Radiation doses from CT scans of chest (3 mSv), head (4 mSv), and abdomen (5 mSv) correlate to 150, 200, and 250 chest x-rays, respectively.(1) The concensus among paediatric radiologists is that about 30% of paediatric CT examinations are unnecessary.(3)

CT head is by far the most commonly performed CT examination among children aged five years and below at KNH.(4)

This study sought to establish the patterns of brain pathology, indications for cranial CT, patient screening practice and radiation dose reduction measures for young children. No similar study had been conducted in Kenya prior to this one.

Hopefully recommendations based on the findings from this study will help to emphasize to clinicians, technicians and radiologists the need to adopt best practices and techniques aimed towards radiation dose minimization during paediatric cranial CT exams and ensuring that only appropriate or relevant examinations are performed.

METHODOLOGY

RESEARCH ASSUMPTIONS

The following are the research assumptions, which informed the study:

a) Cranial CT exams on young children below five years are frequently done at KNH.
b) Most of the cranial CT exams done on young children at KNH are appropriate and yield useful information for diagnosis of the patient's illness.
c) Young children who undergo emergency and non-emergency cranial CT scan at KNH are adequately screened by clinicians and radiologists.
d) Special radiation dose reduction measures are routinely practiced during paediatric cranial CT exams at KNH.

RESEARCH QUESTIONS

The following are the research questions based on the above assumptions.

a) What percentage of cranial CT scans done on children below 5 years yield useful information for diagnosis of the patient's illness?
b) Among young children done cranial CT at KNH, what percentage of the request forms are vetted and signed by a radiologist?
c) Do the request forms for cranial CT for young children at KNH have the relevant clinical information?
d) Which special dose reduction measures are practiced during cranial CT scans in young children at KNH, and in what percentage of the patients?

SCOPE OF THE STUDY

This study sought to investigate the role of cranial CT in the diagnosis of intracranial pathology in children aged 5 years and below at KNH during the six month period between January 2010 and June 2010. The study was also intended to investigate the screening practice for young children and paediatric CT radiation dose reduction measures practiced at KNH.

LIMITATIONS OF THE STUDY

Patients have to pay for CT exams at KNH therefore only those who afforded the fee, or had special clearance from the hospital administration, were included in the study. The latter category included emergency and trauma cases.

STUDY AREA

The study was conducted at KNH located in Nairobi, Kenya. KNH is the largest national referral, teaching and research hospital in Kenya. The radiology department at KNH is well equipped with a 16 slice MDCT scanner, Brilliance model, serial No.729, manufactured by Phillips in January 2007. Other equipment include three ultrasound machines, including volumetric and endo-cavitary scanning, 1.5 Tesla MRI machine, a digital fluoroscopy unit with a C- arm, dental x-ray and general purpose X ray machines.

STUDY POPULATION

Cranial CT scans of all children aged 5 years and below done at KNH for the period January to June 2010.

STUDY DESIGN:

This was a prospective study.

SAMPLING TECHNIQUE

Consecutive sampling was used. All the cranial CT scans of children aged 5 years and below done at KNH were included in the study, until the desired sample size of 101 patients was achieved.

SAMPLE SIZE

The sample size was calculated using the formula by Fisher et al. (54)

$$\mathbf{n} = \frac{z^2pq}{d^2}$$

$$= \frac{0.07x0.93\ (1.96)^2}{(0.05)^2}$$

n = 101 patients

Where**:**

n=the desired sample size.

p = The Proportion in the target population estimated to have characteristics being measured (approximately 7% of all radiological investigations done are CT scans). (4,20)

q=1-p

z= the standard normal deviate at the required confidence level.

d=the level of statistical significance set.

INCLUSION CRITERIA

All cranial CT scans, including CT angiography, done at KNH on children aged 5 years and below were eligible for inclusion in the study.

EXCLUSION CRITERIA

1. Those cranial CT scans for children whose parents or legal guardians declined to sign the consent form for the study.

DATA COLLECTION AND STANDARDIZATION OF RESULTS

The principal researcher was assisted in data collection by two research assistants, who had been trained on all the issues concerning the study. The data was collected using a well structured data sheet (Appendix C). Each case was assigned a case number from 1 – 101 and recorded on the data sheet.

The principal researcher first reported all the CT scans. These reports were then reviewed and countersigned by a consultant radiologist prior to inclusion in the study and/ or release of the radiological report.

DATA ANALYSIS

The following variables were analyzed:

- Age and sex distribution
- Percentage of CT request forms signed by a radiologist
- Distribution of the indications for CT exam request.
- Whether patient had undergone a previous CT exam(s).
- Distribution of clinicians' diagnosis
- Distribution of CT diagnosis
- CT diagnosis versus clinicians diagnosis
- CT radiation dose reduction measures applied during the study

Data analysis was done by computer using Software Program for Social Science research (SPSS-Pc version 11.0) after a data cleaning process to ensure correct and complete data entry.

Results are presented in form of frequency distributions and descriptive statistics to fulfill the aims and objectives of the study.

RESULTS

A total of one hundred and one (101) children referred for cranial CT scan were recruited for the study. A review of these one hundred and one cases is done and results are presented in form of tables and charts to fulfill the aims and objectives of the study.

Table 3: Socio-Demographic Factors (n=101)

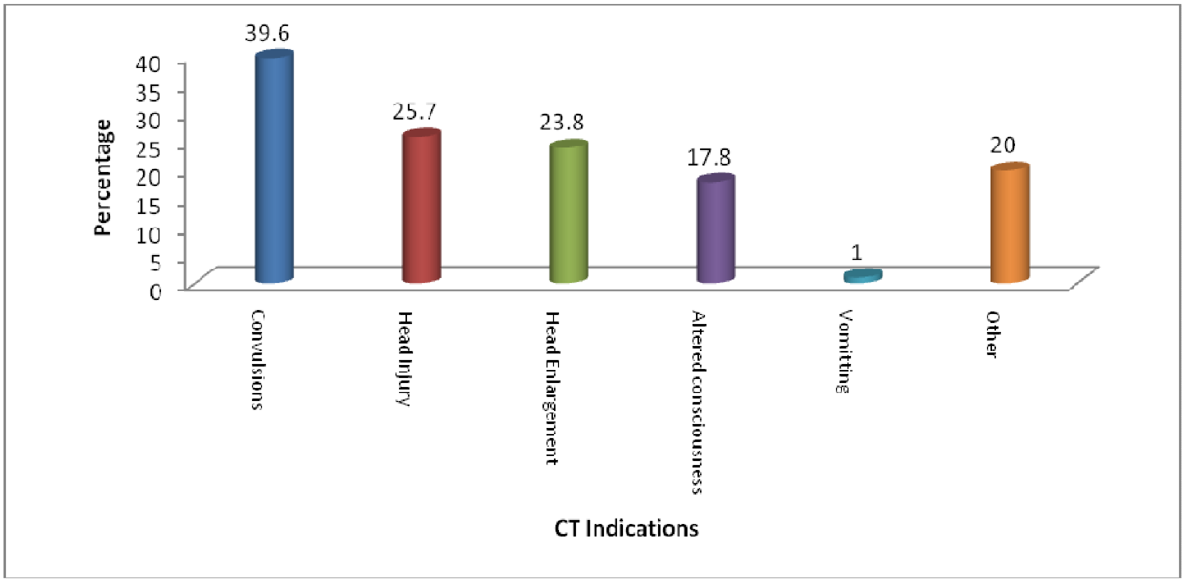
Characteristic	**Factor Level**	**Frequency, n (%)**
Sex	Male	65 (64.4)
	Female	36 (35.6)
Age (in months)	Mean	27.44
	Range	1 to 60
	< 12	36 (35.6)
	12-24	23 (22.8)
	25-36	11 (10.9)
	37-60	31 (30.7)
Referred From	In-patient	50 (49.5)
	Out-patient	51 (50.5)

Male: Female = 1.8: 1

The mean age of the study participants was 27.44 months. The ages ranged from 1 to 60 months.

The proportion of referrals from inpatient (49.5 %) and outpatient (50.5%) departments were almost equal.

Figure 1: Indications for cranial CT



Other CT indications included :

VP shunt location
Hemiparesis
Delayed milestones
Nystagmus

Table 4: Distribution of CT indication by age

	Age				
CT Indication	**< 12**	**12 -24**	**25-36**	**37-60**	**p-value**
Convulsion	17	8	2	13	0.351
Head Injury	2	10	6	8	***0.001***
Head Enlargement	15	2	3	4	***0.010***
Altered Consciousness	7	2	1	8	0.348
Vomiting	1	0	0	0	0.610

Figure 2: Proportion of study patients who had undergone previous cranial CT exam(s)

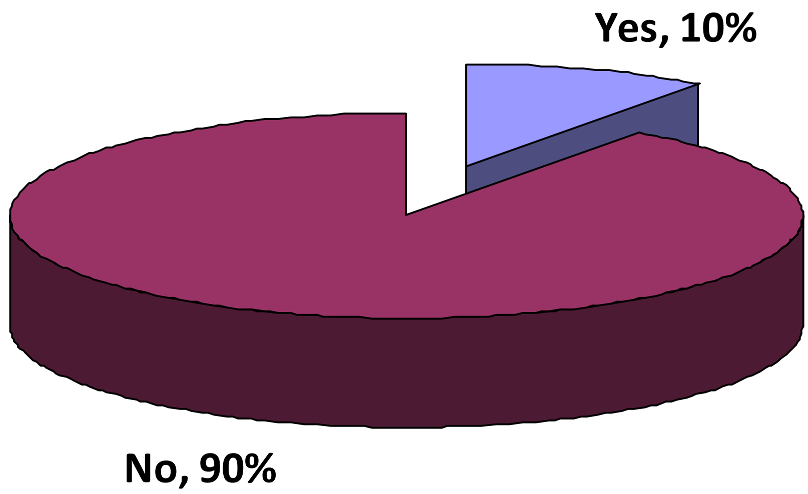


Figure 3: Distribution of CT request forms vetted and signed by a Radiologist

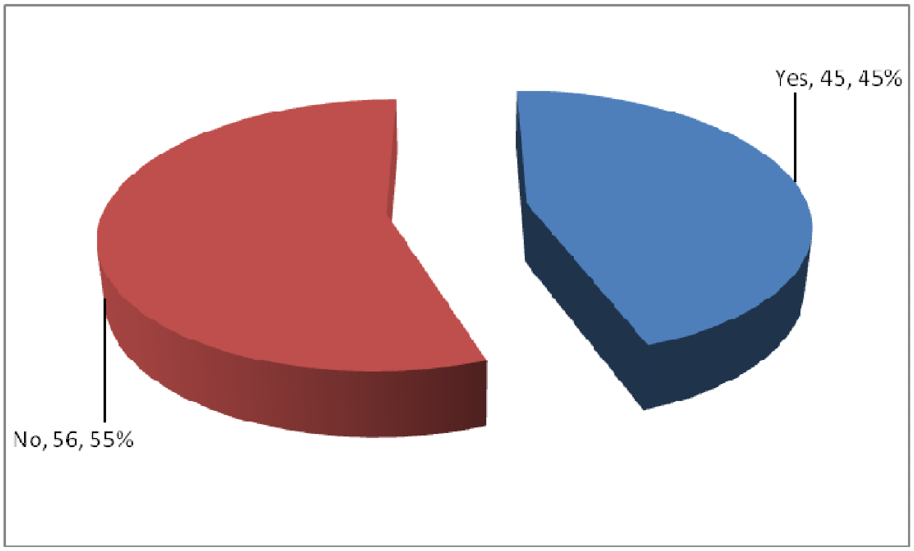


Table 5 : Distribution of CT request forms vetted/not vetted by a radiologist by source of referral

	CT request forms signed by a radiologist		
	Yes, n (%)	**No, n (%)**	Total
In-patient refferals	26 (57.8)	24 (42.9)	50 (49.5)
Out-Patient referrals	19 (42.2)	32 (57.1)	51 (50.5)
Total	45 (100.0)	52 (100.0)	101 (100.0)

Table 6: Distribution of CT Radiation dose reduction measures used during the study (n=101)

Characteristic	Factor Level	Frequency, n (%)
CT radiation dose reduction measure	Customized paediatric CT head protocol	100 (99.0)
	Automatic tube current modulation	100 (99.0)
	Thyroid shielding	95(94.1)
	Gantry tilt to avoid the orbits	-
	Automatic bolus tracking	-
	Other	-

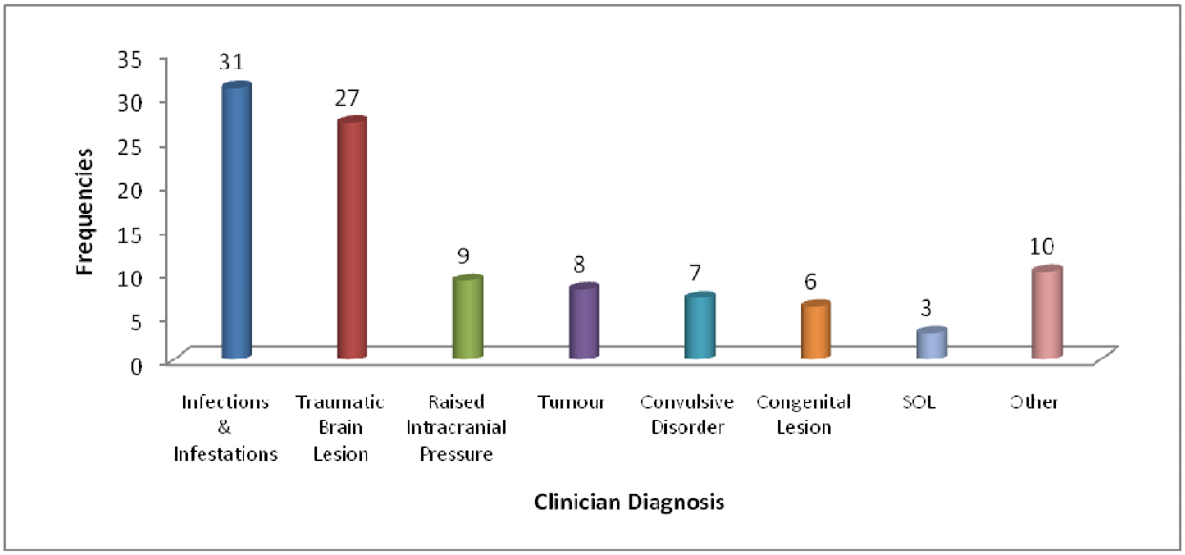
Paediatric CT head protocol and automatic tube current modulation are in-built features of the Multi-Detector CT scanner used during the study.

Thyroid shielding was not routinely applied at KNH prior to this study; however it was applied during the study in all except 6 infants, who were very sick and restless.

The MDCT scanner used in the study does not have features for Gantry tilting. Automatic exposure control protocols instruct the imaging equipment to adjust current up and down depending on variations in patient attenuation, without relying on adjustments made by the imaging technologist.

Automatic bolus tracking is applicable for CT angiography. None of the study patients was referred for CT angiogram.

Fig 4: Distribution of referring clinicians' provisional diagnosis



<u>Others included</u>

hemiparesis
nystagmus
myelomeningocele
failure to thrive
delayed milestones
cortical blindness

Fig 5 : Distribution of referring clinicians' provisional diagnosis by sex

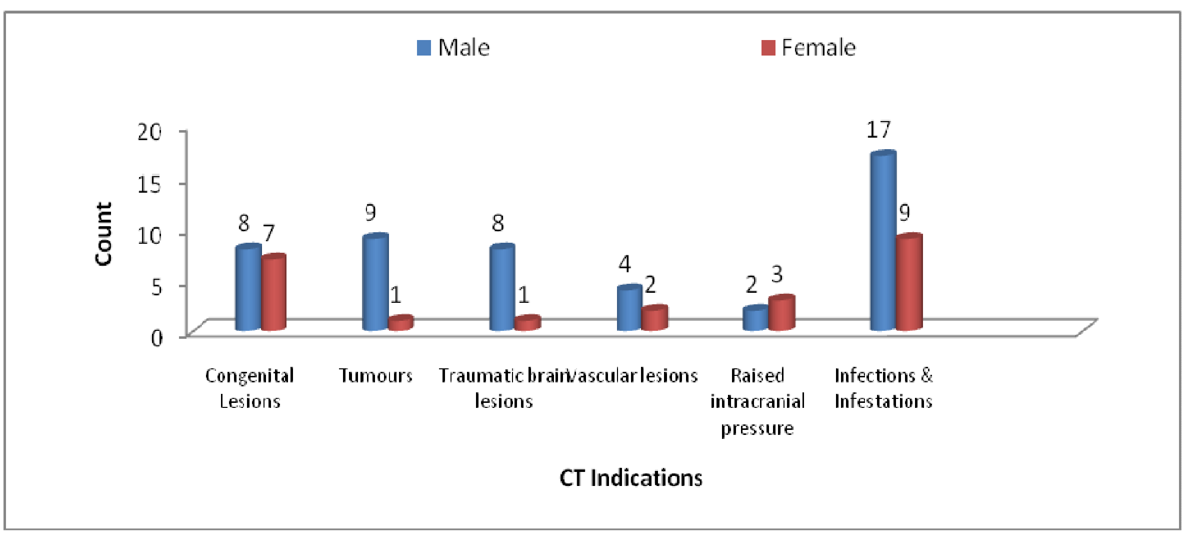


Fig6 : Distribution of CT diagnosis

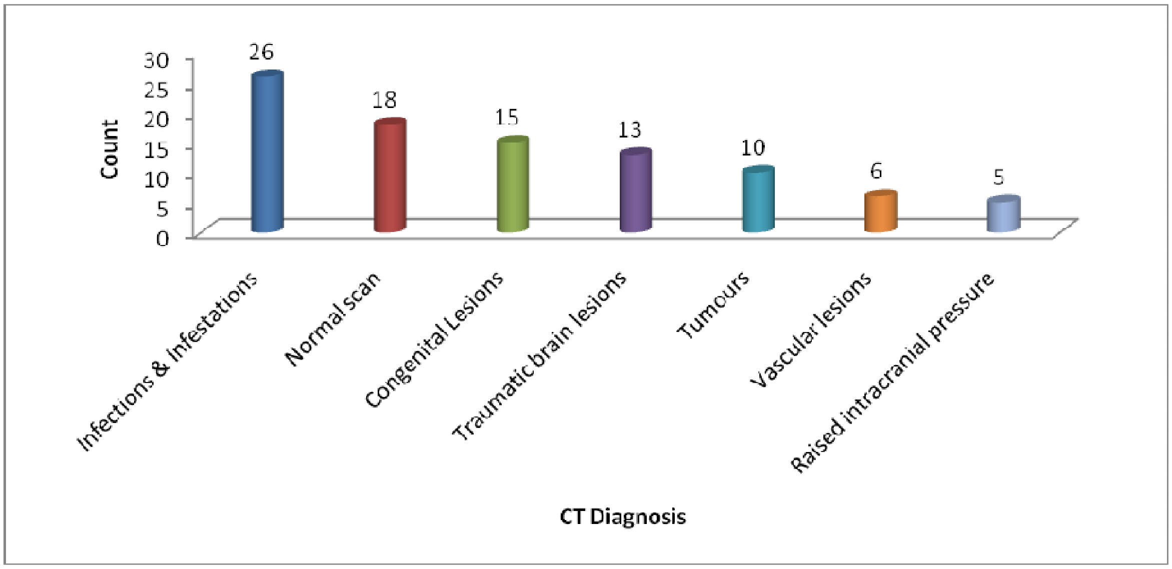


Table 7: Distribution of CT diagnosis by age

	Age Distribution				
CT Diagnosis	**< 12**	**12 - 24**	**25-36**	**37-60**	**p-value**
Congenital Lesions	12	1	1	1	***0.002***
Tumours	0	3	3	4	***0.041***
Traumatic brain lesions	0	4	4	5	***0.01***
Vascular lesions	3	1	1	1	0.782
Raised intracranial pressure	5	0	0	0	***0.023***
Infections & Infestations	10	7	1	8	0.585
Normal scan	4	7	1	6	0.238

Table 8: Clinicians' diagnosis Vs CT diagnosis (general analysis)

CT Diagnosis	Clinical Diagnosis: Congenital Lesion	Tumour	Traumatic Brain Lesion	Raised Intracranial Pressure	Infections & Infestations	Convulsive Disorder	SOL	Other	Total
Congenital Lesions	4	0	2	5	2	1	0	1	15
Tumours	0	6	1	0	0	1	2	0	10
Traumatic brain lesions	0	0	12	0	1	0	0	0	13
Vascular lesions	0	0	0	0	5		0	0	5
Raised intracranial pressure	0	0	0	2	3	0	0	0	5
Infections & Infestations	1	1	1	2	19	0	0	2	26
Normal scan	0	1	11	1	0	1	1	3	18

Four out of 5 cases provisionally diagnosed as congenital lesions were confirmed by CT while 6 out of 8 cases provisionally diagnosed as tumour were confirmed by CT. However 18 cases had normal CT results.

Table 9 : Distribution of provisional diagnosis, CT diagnosis and percent diagnostic accuracy of study patients

Type of diagnosis	No. of provisional	No. of CT	No of CT diagnoses agreeing with provisional diagnosis	Percent diagnostic accuracy (%)
Congenital lesions	5	15	4	80
Tumours	8	10	6	75
Infections&Infestations	30	26	19	63.3
Traumatic brain lesions	26	13	12	46.2
Raised intracranial pressure	10	5	2	20

Table 10 : Clinician's Vs CT diagnosis amongst in-patient referrals

	Clinical Diagnosis								
	Congenital Lesion	**Tumour**	**Traumatic Brain Lesion**	**Raised Intracranial Pressure**	**Infections & Infestations**	**Convulsive Disorder**	**SOL**	**Other**	**Total**
CT Diagnosis									
Congenital Lesions	0	0	0	0	2	1	1	0	4
Tumours	0	4	0	0	0	0	2	0	6
Traumatic brain lesions	0	0	1	0	0	0	0	0	1
Vascular lesions	0	0	0	5	0	1	0	0	6
Raised intracranial pressure	0	0	0	1	3	0	0	0	4
Infections & Infestations	1	1	0	0	17	0	0	0	19
Normal scan	0	1	0	0	0	1	1	0	3

There were only 3 inpatient cases(6%) with normal CT results. They had each been diagnosed as tumour, convulsive disorder and S.O.L. 17 out of 22 cases provisionally diagnosed as Infection and infestation were confirmed by CT, whereas 4 out of 6 cases provisionally diagnosed as Tumour were confirmed by CT. The highest diagnostic accuracy was seen among inpatient trauma cases(100%).

Table 11: Clinician's Vs CT diagnosis amongst out-patient referrals

	Clinical Diagnosis								
	Congenital Lesion	**Tumour**	**Traumatic Brain Lesion**	**Raised Intracranial Pressure**	**Infections & Infestations**	**Convulsive Disorder**	**SOL**	**Other**	**Total**
CT Diagnosis									
Congenital Lesions	4	0	2	4	0	0	0	1	11
Tumours	0	2	1	0	0	1	0	0	4
Traumatic brain lesions	0	0	11	0	1	0	0	0	12
Vascular lesions	0	0	0	0	0	0	0	0	0
Raised intracranial pressure	0	0	0	1	0	0	0	0	1
Infections & Infestations	0	0	1	2	2	0	0	2	7
Normal scan	0	0	11	1	0	0	0	3	15

Fifteen referrals from outpatient(29.4%) had normal CT results, whereas only 11 out of 26 cases(42.3%) provisionally diagnosed from outpatient as traumatic brain lesions were confirmed by CT.

Out of 26 outpatient referrals provisionally diagnosed as traumatic brain lesions 11(42.3%) had normal CT results.

Table 12 : False provisional Diagnosis

	In-patient	Out-patient
Congenital Lesions	0	1
Tumours	2	0
Traumatic brain lesions	0	15
Raised intracranial pressure	2	5
Infections & Infestations	12	0

False provisional diagnosis among in-patient referrals= 14/50 (28.0%)
False provisional diagnosis among out-patient referrals= 21/51 (41.2 %)

Table 13 : Distribution of Clinicians(provisional) vs CT diagnosis among vetted exams

	CT diagnosis								
Provisional	Other	Tumour	Traumatic Brain Lession	Infections & infestations	Raised Intracranial pressure	Congenital Lesions	Normal	Vascular	Total
Other	4	0	0	1	0	1	2	0	8
Tumour	0	2	0	0	0	0	0	0	2
Traumatic Brain Lesion	1	0	2	0	0	1	1	0	5
Infections & infestations	1	0	1	8	3	2	0	1	16
Raised Intracranial pressure	1	0	0	0	1	4	0	0	6
Convulsive Disorder	3	0	0	0	0	1	1	0	5
Congenital Lesions	1	0	0	0	0	2	0	0	3
Total	11	2	3	9	4	11	4	1	45

Table 14 : distribution of provisional vs CT diagnosis among non-vetted exams

	CT diagnosis								
Provisional	Other	Tumour	Traumatic Brain Lession	Infections& infestations	Raise Intracranial pressure	Congenital Lesions	Normal	Vascular	Total
Other	0	0	0	1	0	0	1	0	2
Tumour	1	4	0	1	0	0	0	0	6
Traumatic Brain Lession	0	1	10	0	0	1	10	0	22
SOL	0	2	0	0	0	0	1	0	3
Infections & infestations	4	0	0	7	0	0	0	4	15
Raise Intracranial pressure	0	0	0	1	1	1	0	0	3
Consulsion Disorder	0	1	0	0	0	1	0	0	2
Congenital Lesions	0	0	0	1	0	2	0	0	3
Total	5	8	10	11	1	5	12	4	56

Table 15: Number of CT diagnoses agreeing(tallying) with provisional diagnosis among vetted and non-vetted exams(ref tables 11,12)

Type of diagnosis	No of CT diagnoses tallying with provisional diagnosis			
	Vetted exams		Non-vetted exams	
Tumour	2/2	100%	4/6	66.7%
Congenital lesions	2/3	66.7%	4/6	66.7%
Infections&Infestations	8/16	50%	7/15	46.7%
Traumatic lesions	2/5	40%	10/22	45.5%
Raised intracranial pressure	1/6	16.7%	1/3	33.3%
Other	4/8	50%	0/2	0%

Conclusion (Tables 13,14,15) : From this study it is evident that vetting had a minimal impact on the accuracy of provisional diagnosis. This suggests good preliminary clinical assessment of cranial CT patients at KNH. However vetting remains an important measure for ensuring that only appropriate or relevant examinations are performed.

DISCUSSION

The commonest age group of patients scanned in this study was the under 12 month age group which accounted for 36(35.6%) of the study population (table 3). The next common age group was the 37-60 month age group which accounted for 31(30.7%). These findings can be attributed to the fact that infants are more likely to require CT head due to manifestations of congenital brain lesions while children in the 37-60 month age group are more prone to head trauma and tumours. Similar results were noted in previous studies (15,18)

Out of a total of 101 patients included in this study 65(64.4%) were males while 36(35.6%) were females. The male: female ratio in this study was 1.8:1. This gender bias could largely be attributed to the fact that more male children were referred with head trauma(8:1), tumours(9:1) and infections and infestations(17:9) fig 5.

In this study convulsions was the commonest cranial CT indication accounting for 39.6% of the study population . Several previous studies reported similar findings(37,38,39). Convulsions was also the most common cranial CT indication among the under 12 month age group accounting for 17% of these subjects, followed by head enlargement (15%) , and altered consciousness(7%) whereas head injury accounted for only 2% (table 4).

Similar findings were reported by Mashuke(18) who analyzed indications for cranial CT exam in all age groups at KNH and he found that the commonest presenting signs and symptoms in children were convulsion, fever and hemiparesis.
Head injury as a CT indication is rare among the under 12 month age group since most of these children have not learnt to walk as opposed to those aged above 12 months.

10% of the study patients were found to have undergone a previous CT scan(fig2). This group comprised largely of patients referred from the paediatric neurosurgical clinic who were on follow-up for known neurological conditions. Other indications for repeat scans included checking ventriculo-peritoneal shunt position, poor response to treatment and post surgical complications.

Only 45% of all the cranial CT request forms were found to have been signed by a radiologist while 55% did not bear a radiologist's signature.(fig4). This finding calls for more concerted efforts by KNH radiology department towards improved vetting of paediatric CT exam requests. The role of the radiologist in vetting requests for paediatric CT in order to minimize unnecessary examinations remains of paramount importance. (49)

A majority (57.8%) of the CT request forms signed by radiologists were inpatient referrals. Of the forms not signed by a radiologist, majority (57.1%) were outpatient referrals, including those from the accident and emergency department(table5). This study found that those patients referred from outpatient departments had 41.2% false provisional diagnosis compared to only 28.0% of those referred from inpatient departments (table12). Similar findings were reported by Mashuke (18) who found 51.9% false provisional diagnosis among outpatient referrals versus 11.4% among those referred from inpatient. This underscores the need for thorough preliminary assessment of young children before being subjected to cranial CT exams.

The MDCT scanner used during the study has inbuilt features for customized paediatric CT protocols and automatic exposure control protocols (26, 27), which have been proved to reduce radiation dose by upto 40 %(23,24). In the absence of standardized validated protocols, radiologists often obtain CT images using high radiation exposure levels to minimize image noise and maximize image quality. Studies in multiple jurisdictions have shown that the lack of standardization leads to wide variation in the level of radiation administered for the same CT examination between institutions, with no detectable difference in patient outcomes.(28,29).

Although paediatric cranial CT exams at KNH are done according to established routine standard operating procedures(SOPs), this study revealed the lack of a written outline of these SOPs in the radiology department.

On documentation of radiation dose minimization measures, the study found that thyroid shielding is not routinely applied during paediatric cranial CT exams at KNH due to shortage of thyroid shields.

Earlier on Mwanyika(1995) in his study had similarly observed that thyroid shielding was not routinely practiced at KNH.(35). However during this study thyroid shielding was applied in all except 6 infants who were very sick and restless.

Distribution of clinicians' provisional diagnosis (fig5) showed infections and infestations as commonest(31%) followed by traumatic brain lesions(27%).

The commonest CT diagnosis (fig 6) was infections and infestations (26%) followed by normal scan(18%).

In the distribution of CT diagnosis by age (table 7) congenital lesions were found to be commonest in the under 12 month age group whereas tumours and traumatic brain lesions were absent in the under 12 month age group but commoner in ages above 12 months.

These findings were highly statistically significant (p values 0.002, 0.041 and 0.01 respectively). Earlier studies done by Srehlau(15) and Mashuke(18) recorded similar findings. These findings are expected because most symptomatic congenital lesions manifest in infancy whereas tumours and traumatic brain lesions are commoner after infancy.

General analysis of the clinicians' provisional diagnosis versus CT diagnosis (tables 8 &9) revealed that diagnostic accuracy was highest for those provisionally diagnosed as congenital lesions (80%). This was followed by tumors(75%). Diagnostic accuracy was lowest for those cases provisionally diagnosed as raised intracranial pressure (20%).

Clinicians provisionally diagnosed 27 cases as traumatic brain lesions, however only 12(46.2%) of these were confirmed by CT while 11(40.7%) turned out to be normal scans.

Most of these patients with normal scans were cases of head injury who were in stable clinical condition.

There were 18 cases (17.8%) that had normal CT findings. Out of these 11(61.1%) had been provisionally diagnosed as traumatic brain lesions, 1 as tumour, 1 raised intracranial pressure, 1 convulsive disorder, 1 SOL and 3 as other. The rate of false provisional diagnosis is thus highest among trauma cases.

There is controversy concerning the use of cranial CT in children for minor head trauma. The vast majority of these children have no intracranial injury, but 1% to 2% will have life-threatening intracranial injuries. At least five studies have shown that a negative CT scan of the head has had zero false negatives—even with skull fracture in many cases. If the CT scan shows no intracranial injury, there is a miniscule chance of neurological deterioration. Because of this wonderful reassurance, most children with minor head trauma are scanned with CT when the technology is available.(45)

Further analysis of Clinician's provisional diagnosis Vs CT diagnosis by place of referral showed that 15 out of 51 (=29.4%) of referrals from outpatient departments had normal cranial CT findings, compared to only 3 out of 50 (=6.0%) of referrals from inpatient departments who had normal cranial CT findings.(tables 10&11). This difference was found to be highly statistically significant, p-value=0.020, z=0.04.
83.3%(15/18) of the normal CT results were from outpatient referrals whereas only 16.7%(3/18) of the normal results were for inpatients(tables 10&11). This outcome is expected given the higher level of false provisional diagnosis among outpatient referrals(table 12).

The consensus among paediatric radiologists worldwide is that about 30% of paediatric CT exams are unnecessary (2). The finding of only 6% normal cranial CT exams among inpatient referrals in this study suggests a good diagnostic yield from inpatient departments which could partly be attributed to good clinical workup and an effective patient screening system. On the contrary 29.4% of referrals from outpatient departments had normal cranial CT findings. This could be attributed to a less effective patient screening system and the fact that referrals from outpatient departments tend to have less severe signs and symptoms than inpatients. However a normal CT finding does not necessarily imply futility of the exam, rather, it gives wonderful reassurance, especially in cases of trauma with suspected intracranial injury.(45)

CONCLUSIONS

CT was found to be a useful and adequate diagnostic tool for intracranial pathology in young children. However, it is important for healthcare community to work together to minimize radiation dose to children. Used prudently and optimally CT is one of our most valuable imaging modality for both children and adults.

The MDCT scanner at KNH has inbuilt features for customized paediatric CT protocols and automatic exposure controls. This minimizes technician related errors/omissions associated with older model CT scanners which require manual adjustment of technical parameters.

Although paediatric cranial CT exams at KNH are done according to established routine standard operating procedures(SOPs), this study revealed the lack of a written outline of these SOPs in the radiology department.

RECOMMENDATIONS

All request forms for CT examinations should be vetted and signed by a radiologist or senior radiology residents on call, who should consult with referring clinicians when necessary. Regular interactive Continuous Professional Development (CPD) sessions should be instituted for clinicians, technicians and radiologists not only at KNH, but also at all major peripheral and private hospitals.

Written Standard Operating Procedures for paediatric CT exams should be prominently displayed in the CT section to be observed by all operators. This will greatly help in ensuring standardization of practice.

Routine use of lead shields for the thyroid gland and gonads is highly recommended during paediatric CT exams.

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APPENDIX A: BUDGET

Items	Quantity	Unit Price (Ksh.)	Total (Ksh.)
Stationery and Equipment			
Printing Papers	2 reams	500.00	1,000.00
Black Cartridges (for HP 845C)	2	2,000.00	4,000.00
Writing Pens	1 packet	500.00	500.00
Flash Discs	1	2,000.00	2,000.00
Note Books	5	50.00	250.00
Box Files	5	100.00	500.00
Sub total			**8250.00**
Research Proposal Development			
Printing drafts and final proposal			5,000.00
Photocopy of Questionnaires	400 copies	8.00	3,200.00
Photocopies of final proposal	6 copies	100.00	600.00
Binding of copies of Proposal	5 copies	60.00	300.00
Sub total			**9,100.00**
Personnel			
Research Assistant (2)	2 for 4 months	6,000.00	48,000.00
Biostastician	1	10,000.00	10,000.00
Sub total			**58,000.00**
Thesis Development			
Printing of drafts of thesis			5,000.00
Printing of final thesis	6 copies @10/pg	500.00	3,000.00
Binding of thesis	6 copies	250.00	1,500.00
Dissemination cost			10,000.00
Sub total			**19500.00**
Miscellaneous (10% of the total budget)			**9585.00**
Grand total			**105,435.00**

APPENDIX B: PARENT/GUARDIAN CONSENT FORM

STUDY NUMBER……………..

Title: THE ROLE OF CT SCAN IN DIAGNOSIS OF INTRACRANIAL PATHOLOGY IN CHILDREN AGED FIVE YEARS AND BELOW AT KNH.

Investigator:
DR CYPRIAN AGUMBA ODENY
UNIVERSTY OF NAIROBI,
DEPARTMENT OF DIAGNOSTIC IMAGING & RADIATION MEDICINE
P.O.BOX 19676.
NAIROBI.
TEL 0722270573

Introduction

My name is Cyprian Agumba Odeny. I am a doctor and M.Med. student at the Department of Diagnostic Imaging and Radiation Medicine, University of Nairobi. I am doing a study on the role of CT scan in the diagnosis of intracranial pathology in children aged five years and below at KNH during the six month period between January 2010 and June 2010. I request permission for your child to be included in the study.

The recommendations based on the findings of this study will help to emphasize the need to adopt practices aimed towards radiation dose minimization during paediatric CT exams and ensuring that only appropriate or relevant examinations are performed.

Benefits and Risks

There will be no direct benefits for those participating in the study; neither will there be any risks.

Confidentiality

All information given in the study will be kept confidential and will be used only for the purpose of the study

Voluntary Participation

The participation in the study is voluntary and participants are free to accept or not accept to take part in the study and to withdraw at any time.

Consent

I agree to participate in the study. I have read this form and everything has been clearly explained to me.

Signature: ______________________________________

Date: ____

Signature of researcher: ____________________________

APPENDIX C: DATA SHEET

CASE NUMBER………………………

1. Patient's No……………………………………………………..

2. Patient's X-RAY No…………………

3. Sex: a) Male (   )   b) Female (   )

4. Age …………………………………Weight(Kg)…………………………..

5. Date done…………………………………………………………………….

6. Reffered from : a) In-patient (   )   (b) Out-patient (   )

INFORMATION RELATED TO RADIOLOGICAL IMAGING

7. CT indications : Mark with a tick for yes, and an X for no.

Yes   No

- Altered consciousness…………………………………………………......
- Convulsions……………………………………………………………………
- Head enlargement……………………………………………………………..
- Head injury……………………………………………………………………
- Vomitting……………………………………………………………………..
- Others (specify)

  ………………………………………………………………….

  ……………………………………………………………………………………

  …………………………………………………………………………………….

  ……………………………………………………………………………………….

  ……………………………………………………………………………………….

  ……………………………………………………………………………………

8. Has the patient undergone a CT exam in the past? If yes, how many?.............................

Are the CT scans available?..

Is the exam still relevant and why?...

....

9. What was the clinician's diagnosis……………………………………………………

……………………………………………………………………………………………..

10. Was CT request form signed by a radiologist?. a) yes (   )   b) no (   )

11. Which CT radiation dose reduction measures were used?. (Tick for 'yes', mark X for 'no')

If the answer is ' no' indicate why?.

- Customised paediatric CT head protocols………………………………………...
- Automatic tube current modulation……………………………………………….
- Thyroid shielding………………………………………………………………….
- Gantry tilt to avoid the orbits…………………………………………………….
- Automatic bolus tracking for CT angiography ……………………………………..
- Other measures(specify)…………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

…………………………………………………………………………………………….

12. CT diagnosis : (Tick where appropriate)

- Congenital lesions…………………………………………………………………
- Tumours…………………………………………………………………………….
- Traumatic brain lesions…………………………………………………………………
- Vascular lesions…………………………………………………………………
- Raised intracranial pressure…………………………………………………………………

- Infections and
  infestations………………………………………………………………
- Normal
  scan………………………………………………………………………
- Other conditions
  (specify)…………………………………………………………………….
  ………………………………………………………………………………
  ………………………………………………………………………………
  ………………………………………………………………………………