MULTIDETECTOR COMPUTERIZED TOMOGRAPHY SCAN FINDINGS OF THE HEAD IN PATIENTS WITH HEAD INJURY AT KENYATTA NATIONAL HOSPITAL

A DISSERTATION SUBMITTED IN PART FULFILLMENT FOR A MASTERS DEGREE IN DIAGNOSTIC RADIOLOGY OF UNIVERSITY OF NAIROBI

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ABSTRACT

INTRODUCTION

Assessment of the critically injured patient is time – dependent and should not delay definitive care, which in many cases requires surgery. Computed tomography has certainly fulfilled that criterion and it has become the most important diagnostic innovation in evaluating head injuries. It has generally replaced insensitive, non specific and difficult to interpret studies with one accurate, simple and non-invasive study[3]. The use of Multidetector Computed tomography has further improved on this by providing faster acquisition of images, higher spatial resolution and better image quality[4].

BACKGROUND

Head injury is a major cause of morbidity and mortality worldwide. The incidence of head injury is 300 per 100,000 per year with a mortality of 25 per 100,000 in North America and 9 per 100,000 in Britain[2].

OBJECTIVE

The main objective of the study was to describe the occurrence and pattern of findings of Head Injury on Multidetector Computerized Tomography of the Head in patients seen at Kenyatta National Hospital (KNH). The other objectives were to determine the causes, age and sex distribution, the presenting complaints and radiological findings of head injury and to correlate these findings with the Glasgow Coma Scale (GCS).

METHODOLOGY

The study was conducted at KNH (Nairobi), which is the main Referral Hospital in Kenya. The study was performed on a 16 slice Multidetector CT scanner, Brilliance Model, Serial No.729, manufactured by Phillips, 2007 January. The study was a prospective one and was carried out for a period of 4 months, from July 2008 – October 2008. A total of 192 patients were recruited for the study.

RESULTS

A total of 192 patients were recruited for the study. The patients' age ranged from 10 months to 85 years. More males (82.3%) were recruited. The male to female ratio was 5:1. The commonest cause of head injury was Road Traffic Accidents (RTA) (51.8%) followed by Assault (27.5%). Main symptom necessitating a Head CT scan following

head injury was Loss of Consciousness (54.2%) followed by headache (29.2%) and Confusion(19.3%). The commonest age group affected was 20-29 year (31.3%) followed by 30-39years (29.7%). Most patients had moderate head injury (GCS score 9-13) (50.5%). The most common CT scan finding was Scalp injury (Subgaleal Hematoma) (9.21%), followed by linear skull fracture(9.07%) and diffuse cerebral oedema(8.64%). Patients with moderate and severe head injuries GCS's of 9-13 and < 8 respectively had severer CT scan findings such as Intraventricular hemorrhages and diffuse axonal injury.

CONCLUSION

Multidetector Computed Tomography (MDCT) was found to be a useful and adequate diagnostic tool in the evaluation of patients presenting with head injury. There was additional pick up of diffuse axonal injury which was not demonstrated on earlier studies done on conventional CT scans.

The Glasgow Coma Scale was found to be an important clinical assessment scale in the head injured patient because it is a predictor of severity of injury.

ABBREVIATIONS AND DEFINITIONS

ABBREVIATIONS

CSF	Cerebral Spinal Fluid
CT	Computerized Tomography
CVA	Cerebral Vascular Accident
GCS	Glasgow Coma Scale
KES	Kenya Shillings
KNH	Kenyatta National Hospital
MBChB	Bachelor's Degree in Medicine and Surgery
MMED	Masters Degree in Medicine
MRI	Magnetic Resonance Imaging
RTA	Road Traffic Accident
UON	University of Nairobi
U/S	Ultrasound

DEFINITIONS

Head Injury

Head injury is the result of trauma or physical insult to the head leading to physical damage or injury to the scalp, skull or brain. The injuries can range from a minor bump on the scalp to serious brain injuries. Head injury can be classified as either closed or open (penetrating) [2].

Closed Head Injury

This means one received a hard blow to the head from a striking object but without a skull fracture or breaking the skull.

Open Head Injury

This means one was hit with an object that broke the skull and entered the brain. This usually happens when one moves at high speed, such as going through the windshield during a car accident. It can also happen from a gun-shot to the head.

ETHICAL CONSIDERATIONS

The Kenyatta National Hospital Ethical and Research committee approved the research protocol.

The patients names did not appear anywhere in the data collections forms in order to maintain confidentiality. Patients were instead coded with serial numbers. For referral purposes, only the patients' hospital and CT scan numbers were recorded.

The information acquired was not used for any purposes other than for the research.

The ALARA principle that is keeping the radiation exposure As Low As Reasonably Achievable was maintained for all the patients. Only the standard radiological procedure for Head CT was applied to all patients. No additional examination was done on a patient other than what had been requested by the primary physician.

INTRODUCTION

Head injury is a major cause of morbidity and mortality worldwide and our country Kenya is no exception. Every year millions of people sustain head injuries. Luckily most of these injuries are minor because the skull provides the brain with considerable protection. The incidence of head injury is 300 per 100,000 per year (0.3 of the population) with a mortality of 25 per 100,000 in North America and 9 per 100,000 in Britain [2] .The commonest causes of head injury are road accidents, assaults and falls [5].

The Center for Disease Control (CDC's) National Center for Injury Prevention and control estimates that 5.3million United States (U.S.) Citizens (2% of the population) are living with disability as a result of a traumatic brain injury (TBI). This represents the prevalence of TBI disability, defined as the proportion of persons in the population at a given time who have disability resulting from TBI [6]. The census for South Africa in 2001 shows the TBI prevalence to be 5% out of a population of 44.8million (2,240,000 people are disabled) [7].

CT scanning of the head remains the most useful imaging study for patients with severe head trauma. It provides information regarding the integrity of soft tissues and the skull, the appearance of the brain, presence or absence of hemorrhage and mass effect as indicated by the shift of midline structures. A non-contrast study is useful in the immediate post trauma period for rapid diagnosis of intracranial pathology that requires prompt surgical intervention. [3]. The Multidetector CT offers good spatial and temporal resolution, improved anatomical coverage, very fast scanning times within a patient's breath-hold hence reducing the need for sedation in the trauma patient. It also offers high quality multiplanar reformats which enhance pick-up of traumatic brain lesions and skull fractures[4].

Earlier studies done by Mashuke[8] 1997 and De Sousa[5] 1992 were undertaken using Conventional CT scanners. In 1997 Mashuke found that traumatic lesions accounted for 15.7% of the diagnoses for patients referred for CT scans of the head in KNH. In 1992 De Sousa[5] attributed road traffic accidents to be the leading cause of head injury (52.5%), for patients' referred to Aga Khan Hospital for CT scanning following head trauma. The commonest finding in De Sousa's study was contusional injury (23.7%).

No focused study on the patterns of Head Injury on Multidetector Computerized Tomography had been done at KNH which is the main referral hospital in Kenya. On any given day KNH caters for an out-patient population of 1400 and an in-patient population of 3000[9].

The aim of this study was to determine the occurrence and pattern of head injury findings using MDCT and to correlate these findings with the Glasgow Coma Scale.

LITERATURE REVIEW

Unintentional injury is the fifth most common cause of death worldwide, however, in sub-Saharan Africa; injuries have been reported to rank third behind diarrhea and malaria. Most of these injuries are attributed to road traffic accidents. In Kenya over the last 30 years, there has been a five-fold increase in non-fatal casualties due to road traffic accidents and four to five fold increase in road fatalities[10]. It is mentioned that for every one (1) fatal motor vehicle accident, four (4) people suffer from brain injuries[7].

The 1991 National Health interview survey was analyzed to describe the incidence of mild and moderate brain injury in the United States[11]. Data were collected from 46,761 households. The main outcome measure was a report of one or more occurrences of head injury resulting in loss of consciousness in the previous 12 months. Motor Vehicles were involved in 28% of the brain injuries, sports and physical activity were responsible for 20% and assaults for 9%. Medical consultations were sought by 75% of those with brain injury and only 25% of these were hospitalized. The risk of head injury was highest among teenagers, young adults, males and persons' with low income who lived alone. The incidence of mild and moderate brain injury in the United States was found to be quite substantial.

In 1979 Mwangombe[12] prospectively evaluated 378 patients admitted with head trauma at KNH over a period of six months. The evaluation was done clinically. Road traffic accidents accounted for 46.3% admissions, assault 40.4%, falls 10.3%, industrial accidents 1.4% and sports 0.5%. The overall mortality rate was 15.6%.

In a 1year prospective study on Head Injury at Mbarara Regional Referral Hospital (MRRH) in Uganda, 280 head injury cases were clinically evaluated in 2005[13]. Head trauma accounted for 22.5% of all total trauma admissions. 61.5% of the head injuries were attributed to road traffic accidents. 80.7% of the patients were male. The age group 15-29 years accounted for the majority of the affected (46.2%). 57.9% of patients had mild head injury while 14.3% had severe head injury. Acute head injury was found to be the leading cause of trauma admissions at MRRH and its mortality was high at 17%.

A retrospective study of 1,845 patients was performed to evaluate the efficacy of skull films in acute head trauma by Struat[14] in 1979 at Yale New Haven Hospital. 79 patients had skull fractures. 33 patients sustained significant intracranial sequelae from their injuries but only 7 of these had fractures. In none of the 33 patients with significant intracranial sequelae was management or outcome affected by skull film findings. Of 1,845 patients only 7 (0.38%) had basilar fractures requiring antibiotics. These were the only patients whose treatment and outcome were apparently altered by radiographic findings. In this study it was found that skull fractures alone seldom indicate more serious intracranial injury. It was hence concluded that if any of high-yield features for significant intracranial sequelae are present, then CT should be considered as the primary, non-invasive, diagnostic procedure of choice.

In a 1 year retrospective study in three military hospitals in Jordan, eight hundred and sixteen patients with head injury were evaluated both clinically and radiologically in 2001[15]. 541 (66.3%) were male and 275 (33.5%) were female patients. 32.3% were below 15 years, while 48.2% were between 16-65years and 19.5% were above 66years. Falling down was the common cause of head injury followed by RTA and missile. 72.1% had mild head injury, 19.5% had moderate injury and 8.4% had severe injury. 589 patients had skull radiographs of which 84.9% were normal, 12.8% had linear fractures and 2.3% had depressed fractures. 561 had CT scans; of which 75.1% had normal scan findings, 6.2% had brain contusions, 4.8% had subdural hematomas, 8.3% had extradural hematoma and 5.6% had intracerebral hematomas. 361 patients with mild head injury had skull radiographs and abnormal findings were found in 4.4%. 363 patients with mild head injury had CT scans and only 7.5% had abnormal findings. There was a direct correlation between clinical type of head injury and the radiological findings. Skull radiography was found to have a limited role in head injury particularly in minor head injury[12] since only 15% or less had positive findings.

Quayle KS et al[16] in a prospective cohort in 1997 evaluated 322 children with non trivial head injury seeking care in an urban pediatric emergency department. The children were assessed with skull radiographs, head CT and data forms incorporating mechanisms of injury, symptoms and physical findings. Intracranial injury (ICI) occurred in 27 patients (8%) whereas 50 (16%) had skull fractures. Of those with ICI, 16 (59%) had normal mental status and no focal abnormality and one of these 16 required surgical intervention for evacuation of an epidural hematoma. 6 (38%) of the 16 patients were younger than 1 year, 5 of whom had scalp contusion or hematoma without other symptoms. Findings associated with ICI were skull fracture, loss of consciousness for more than 5 minutes, altered mental status and focal neurological abnormality. It was found that in infants intracranial injury may occur with few or subtle signs and symptoms.

In a 1 year prospective Study on All Cranial Computed Tomography at KNH in 1997, Mashuke[8] reviewed 165 patients who had been referred for CT scans of the head. 25.5% were referred due to suspected space occupying lesion and 15.2% were referred following trauma. 24.2% of the scans had features of raised intracranial pressure, 15.7% had traumatic brain lesions, 14.5% had tumors, 13.3% had congenital lesions, 10.9% had infections and infestations, 5.5% had vascular lesions and 15.7% had other conditions. In this study no breakdown on the specific CT findings of the traumatic brain lesions was done.

CT scans in Head Injured patients at Usman Dan Fodio University Teaching Hospital (UDUTH), Sokoto, Nigeria were retrospectively reviewed in 2002[17]. The CT scanner was a conventional one. Positive findings were noted in 58 patients (78.4%). Road traffic accidents accounted for the commonest cause of head injury with the highest incidence in males in the 30-39year old age group. Assault as a cause of head injury had the highest diagnostic yield (100%). Intracranial hemorrhage was the most frequent abnormality noted in 48.7%, followed by skull fracture in 29.7% of the patients.

In a 1 year prospective study on Acute Head Injury in Nairobi, De Sousa[5] in 1992 reviewed 160 patients with acute head injury. This was done at the Aga Khan Hospital in Nairobi. The patients were evaluated clinically using the Glasgow Coma Scale (GCS) and radiologically using a Conventional CT scanner. Most of the head injury was attributed to road accidents (52.5%), followed by assault (28.1%) and falls (10.6%). The common presenting symptoms were; decreased level of consciousness(39.3%), headache(25%), confusion(24.3%), convulsions(8.8%), unilateral weakness(8.8%) and vomiting(8.1%). 91(56.8%) patients had a GCS score of 13 – 15, 52(32.5%) had a GCS score of 8 – 12 and 17(10.6%) had a GCS score of 3 – 7. On review on CT; 25% of patients had normal scans, 23.7% of patients had contusion injury, 19.3% had intracerebral hemorrhage, 17.5% had midline shift, 13.1% had extradural haematoma (EDH), 10.6% had subdural haematoma (SDH), 8.8% had generalized brain oedema and 8.8% had compression of brain cisterns. Most of the patients with a GCS of 3 – 7 had compression of basal cisterns (58.8%) and generalized brain oedema (41%). There were no normal scan findings in this group of patients. In those patients with GCS of 8 – 12 the scan findings included; contusion (36%), intracerebral hemorrhage (25%), SDH (17.3%) and EDH (13.5%). 19.2% of patients in this category had normal CT scans. In those patients with GCS of 13 -15, 32.9% had normal scans, 14.2% had contusion injury, 13.1% had intracerebral hemorrhage and 13.1% had EDH. In this study the GCS was seen as a useful guide in evaluating patients with acute head injury. The value of CT in demonstrating surgically treatable lesions was also shown.

In a 3 year prospective study at two referral hospitals for trauma in Curitiba, Southern Brazil, 2000 patients with mild head trauma were evaluated with cranial conventional CT scans[18]. The mean age of the patients was 30.8$\pm$19 years. Male to female ratio was 2:1. The most common causes of head injury were; falls (30.5%), interpersonal aggression (17.9%), automobile accidents (16.2%) and pedestrian injuries (13%). Alcohol intoxication was associated with head trauma in 158 cases (7.9%). A normal CT scan was seen in 60.75% (1215) and abnormal CT scan in 39.25% (785) of patients. 518 (65.9%) lesions were related to head trauma whereas 267 (34.1%) were incidental findings. The most common CT scan head trauma related findings were; soft tissue swelling 8.9%, skull fracture 4.3%, intracranial and scalp (Subgaleal) hematomas 3.4% and 2.4%, brain swelling 2% and brain contusion 1.2%. Incidental CT scan findings included; brain atrophy 5.9%, one calcification 5.2%, several calcifications 2.4%, ischemic infarcts 1.9%

and leukoaraiosis 1.3%. These findings showed the importance of CT scan examinations in mild head injury.

A two phase study was carried out at Charity Hospital, Los Angeles, in 2000 to develop and validate a set of clinical criteria that could be used to justify the use of CT in patients with minor head injury[19]. The initial phase of the study used a prospective, consecutive sample of 520 patients (age range 3 – 94years) to determine which specific clinical findings correlated with positive findings on cranial CT scan. A conventional CT scan was used in this study. A minor head injury was defined as a loss of consciousness in the presence of a normal neurological exam and a normal score (15) on GCS. Positive CT scan findings included; a subdural, epidural or parenchymal hematoma, subarachnoid hemorrhage, cerebral contusion and depressed skull fracture. 36(6.9%) patients had positive CT scan findings. Analysis from this study yielded a set of seven clinical findings that had a high positive predictive for positive findings on CT scan. These were; short term memory deficits, drug or alcohol intoxication, physical trauma above the clavicles, age above 60 years, seizure, headache and vomiting. These seven findings were then prospectively validated in a separate group of 909 similar consecutive patients with minor head injury. In this group, 57(6.3%) of patients had a positive CT scan. All the 57 had atleast one of the seven findings determined by the first phase of the study. There were 640 patients with one or more clinical findings present who had normal CT scans. 212 patients of the patients had none of the seven clinical criteria and all of their scans were negative. From this study it was concluded that in patients presenting with minor head injuries, the need for cranial CT scan can accurately be determined by applying the clinical criteria validated by this study. It was noted that a reduction in the number of scans performed in minor head trauma by applying the clinical criteria, produces a substantial decrease in health care costs.

In a 3 year retrospective study in 2005, 800 patients admitted to the neurosurgical ward of Imam Hussein Hospital, Iran, due to acute craniocerebral trauma were evaluated both clinically and radiologically[20]. From the studied patients 641 (80.1%) were males and 159

(19.1%) were females. The peak age was 25 years. The most common mechanism of head trauma was motor vehicle accidents (60.1%). Mild head injury was seen in 75% of patients, while 14% and 5.25% had moderate and severe head injuries respectively. CT scan findings were normal in 14.1%. The most common lesions were; Contusion 32.9%, Epidural hematoma 27.1%, Subdural hematoma 13.3%, Subarachnoid hemorrhage 11.4% and Pneumocephalus 12.1%. The presence of mixed lesions and midline shift regardless of the background lesions were related to statistically significant decreases in Glasgow Coma Scale (GCS). It was then concluded that as one of the leading causes of mortality in Iran, craniocerebral trauma needed more consideration.

40 patients with closed head injury at University of Iowa Hospitals and Clinics were prospectively evaluated with both CT and Intermediate field strength MRI in 1987[21]. The aim was to compare the diagnostic efficacies of the two techniques. The CT scanner used was a single slice conventional CT scanner. Traumatic lesions were detected in 38 patients. CT and MR (T_1 and T_2 weighted) studies were both highly and comparatively sensitive in detection of hemorrhagic intra-axial lesions. MR scans however were much more sensitive in detecting non hemorrhagic lesions. MR was significantly better in detecting brainstem lesions. Intraventricular hemorrhage was consistently seen with all three imaging studies but subarachnoid hemorrhage was much more frequently seen with CT. MR was found to have clear advantages over CT in evaluating closed head trauma, however CT had one advantage over MR in its ability to more rapidly assess unstable patients who may need surgery.

A one year prospective study was carried out in Europe in 2002 to describe and discuss the first experiences with Multidetector CT (MDCT) in the assessment of traumatized children[22]. 85 children (31girls, 54boys with a mean age of 9.2 years) consecutively underwent MDCT with different protocols depending on age, weight, trauma mechanism and clinical presentation. In all patients in whom pathology was suspected, multiplanar reformations in coronal and/ or sagittal orientation was performed. In 55 (65%) children, a MDCT solely of the head was performed, in 46 there was no pathology found. In 6 (7%) head and facial bones were scanned. Head and abdomen was examined in two (2%), in two (2%) the abdomen only and in one (1%) the pelvis solely. Scans of the spine were obtained in seven (8%) children. A thorax and abdomen examination only was obtained in one (1%) child each. In 11 (13%) children, a polytrauma protocol was performed. In all patients, the time of examination did not exceed 17 minutes, including set up time. From this study MDCT was found to be promising in the management of traumatized children. It did shorten the necessary time to reach a diagnosis and to initiate life-saving treatment.

The corpus callosum is one of the common sites of brain lesions, whose involvement is an indicator of a more severe prognosis, produced by traumatic shearing stresses resulting in diffuse axonal injury (DAI). Conventional computed tomography in the acute phase is considered to have a limited role for the detection of non-hemorrhagic or petechial hemorrhagic DAI lesions. In 2004 an evaluation of traumatic corpus callosum lesions was done using a Multidetector CT (MDCT) [23]. New generation MDCT scanners allow faster acquisition of thinner slice images and post-processing reformats. Three patients with severe closed head trauma underwent CT examinations using a Multidetector scanner, a few hours and days after injury. The review of original images with narrow window width and integration with reconstruction of thinner slices for raw-data and post processing multiplanar reformations helped to detect onset of hypodense or predominantly hypodense areas of corpus callosum, not present at admission and confirmed afterwards by MRI[23]. In addition MDCT due to its high resolution, reduced beam hardening artifacts and multiplanar capabilities facilitates the diagnoses of traumatic brain herniations, posterior fossa lesions and base of skull fractures[4].

CT is the initial imaging modality of choice in the head injured patient because; it is sensitive to acute subarachnoid hemorrhage; it is compatible with life- support and traction/ stabilization devices; it has a short image acquisition time; it is superior in the evaluation of cortical bone injury and foreign bodies; and it is widely available[24]. Another significant benefit of CT is a decrease in hospital charges and occupancy by shortening the time for diagnostic studies. Since there is prompt diagnostic work-up of patients, the average length of hospitalization is decreased and in the long run the hospital costs are decreased too[25]. This has made CT a cost effective imaging modality in the head injured patients. MDCT has further improved on this by providing greater diagnostic accuracy, more efficient workflow, increased productivity and better quality, cost-effective patient care[4].

ANATOMY OF HEAD INJURY

THE SKULL

The skull consists of the calvarium, facial bones and mandible (Figure 1). The bones of the calvarium and face are joined at immovable fibrous joints, except for the temporo-mandibular joint, which is a movable cartilaginous joint. The skull vault is made up of several flat bones, joined at sutures, which can be recognized on skull radiographs (Figure 2). The bones consist of the diploic space - a cancellous layer containing vascular spaces sandwiched between the inner and outer tables of cortical bone. The skull houses the brain which consists of the cerebral hemispheres, brainstem and the cerebellum[26].

Figure 1

3D CT reconstruction of the skull

Figure 2

Lateral radiograph of the skull

The base of skull

For anatomical purposes, the basal portion of the skull (Figure 3) is divided into three fossae; the anterior, middle and posterior cranial fossa. The anterior cranial fossa is defined by the frontal bone anteriorly and the margins of the lesser wings of the sphenoid posteriorly. It contains the frontal lobes and the olfactory bulbs and tracts. The middle cranial fossa is defined by the free margins of the lesser wings of the sphenoid anteriorly and the petrous pyramids of the temporal bone, posteriorly. It contains the temporal lobe. The posterior cranial fossa extends from the petrous pyramids anteriorly to the occipital bone posteriorly. It contains the brain stem, cerebellum, fourth ventricle, lower cranial nerves and the vertebral-basilar arterial tree[26, 27].

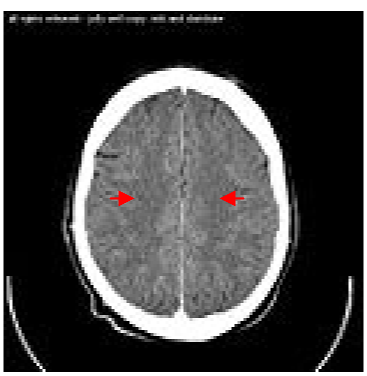
Figure 3

CT -3D reconstruction of base of skull

Cerebral hemispheres

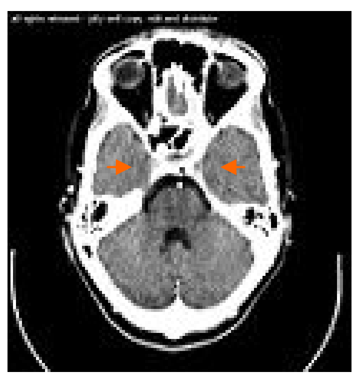
Two cerebral hemispheres (figure 4) fill the cranial vault above the tentorium cerebelli. These cerebral hemispheres are separated by the interhemispheric fissure and the falx cerebri. Below the falx the two hemispheres are joined by the corpus callosum. The hemispheres consist of cortical grey matter, white matter, basal ganglia, thalamus, hypothalamus, pituitary gland and the limbic lobe. The lateral ventricles form a cavity within each hemisphere. Each cerebral cortex is divided into 5 lobes namely: the frontal, parietal, temporal, occipital and the insula[26].

Figure 4



CT scan demonstrating cerebral Hemispheres

Figure 5



CT at the level of temporal lobes

The brainstem

The brainstem connects the cerebral hemispheres with the spinal cord and extends from just above the tentorial hiatus to just below the foramen magnum. It is bounded anteriorly by the clivus - basisphenoid above and the basi-occiput below. The brainstem has three parts: from superior to inferior, the midbrain (figure 6), the pons and the medulla (figure 7).

Figure 6

CT at the level of the midbrain (red arrows)

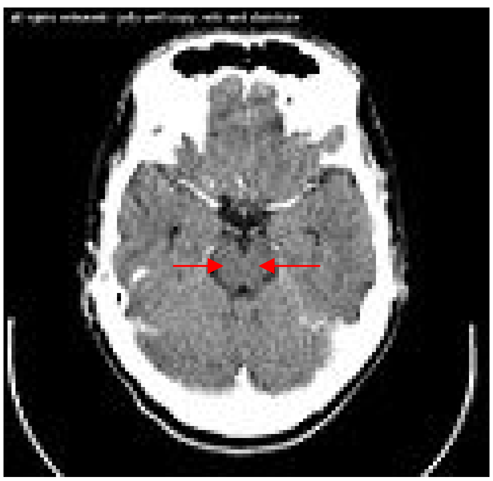
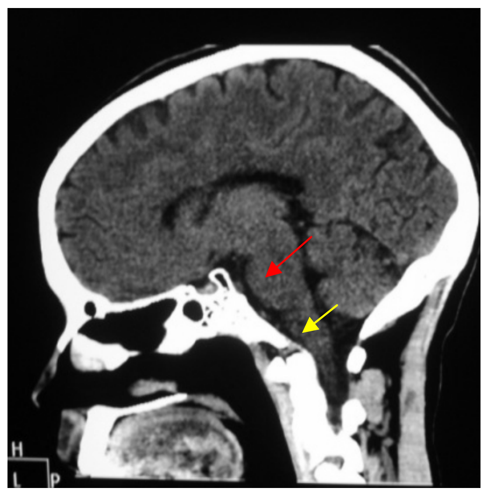


Figure 7

Sagittal CT showing pons & medulla (red& yellow arrows)



THE CEREBELLUM (Figure 10&11)

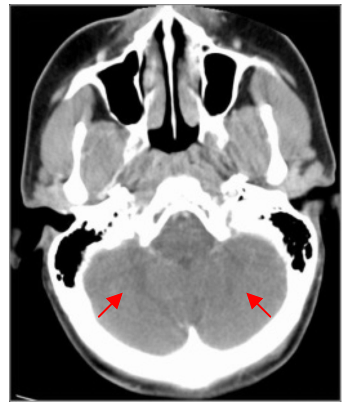
The cerebellum lies in the posterior cranial fossa. It is separated from the occipital lobe by the tentorium and from the pons and midbrain by the fourth ventricle. It is connected to the brainstem by three pairs of cerebellar peduncles: superior cerebellar peduncle to the midbrain, middle cerebellar peduncle to the pons and the inferior cerebellar peduncle to the medulla. The cerebellum lies on the occipital bone posteriorly and close to the mastoid anteriorly. There are two hemispheres with the midline vermis. The hemispheres are separated by a shallow median groove superiorly and by a deep grove inferiorly[26, 27].

Figure 8

Sagittal Scan

Cerebellum

Figure 9



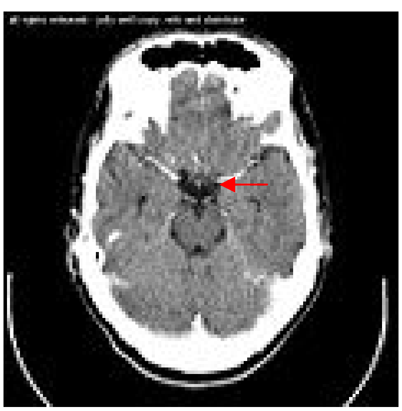
Axial Scan

Cerebellar hemispheres

INTRACRANIAL ARTERIES (Figure 10&11)

The internal carotid arteries supply the anterior cerebral circulation and the vertebral and basilar arteries supply the posterior circulation. The external carotid arteries supply most extracranial head and neck structures (except the orbits) and have an important contribution to the supply of the meninges[27].

Figure 10



Contrast enhanced CT

at the level of circle of Willis

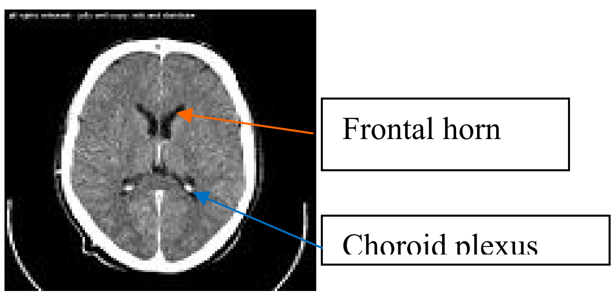
Figure 11

CT Angiography

VENTRICLES (Figure 12)

These are fluid- filled spaces within the brain related to the development of the nervous system as a tubular structure with a central canal. Two lateral ventricles represent expansion of the most anterior part of the ventricular system into each cerebral hemisphere. The third ventricle, the aqueduct and fourth ventricle are midline in position and are continuous with the central canal of the cord. The ventricular system communicates with the subarachnoid space around the brain via foramina in the fourth ventricle (magendie and lushka). [27].

Figure 12

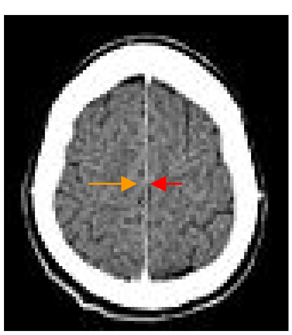


CT at the level of lateral ventricle demonstrates frontal horns and Choroid plexus in the trigone

MENINGES (Figure 13)

These are membrane layers that cover the brain and spinal cord. They are three in number from without inwards these are: the dura mater, the arachnoid mater and the pia mater[18].

Figure 13



CT demonstrating the dural falx

CLINICAL FEATURES OF HEAD INJURY

It may not be possible to describe the myriad of possible clinical features following a head injury[28]. This may be due to the fact that presentation varies according to the mechanism of injury. Initially, most patients with traumatic brain injury lose consciousness (usually for seconds or minutes), although with minor injuries, some have only confusion or amnesia (amnesia is usually retrograde and lasts for seconds to a few hours). Young children may simply become irritable. Some patients have seizures, often within the 1st hour or day. After these initial symptoms, patients may be fully awake and alert, or consciousness and function may be altered to some degree, from mild confusion to stupor to coma.

Serious injury to the brain may occur even when there is no visible bleeding or injury on the outside of the skull. Some symptoms of a serious head injury include; loss of consciousness, memory loss, a severe headache, or a headache that continues to get worse, confusion or abnormal behavior, a young child may be very fussy, fretful or may cry constantly and adult may be combative. Other symptoms include extreme sleepiness or difficulty waking up, slurred speech, numbness, weakness or loss of movement in the arms or legs, vision changes and changes in the pupils' size, shape and reaction to light; dizziness, vertigo, or unsteadiness that prevents standing or walking and persistent nausea and vomiting[28].

De Sousa[5] described some common symptoms found in head trauma patients referred for scanning. These included; decreased level of consciousness, headache, confusion, convulsions, unilateral weakness and vomiting. Other less common symptoms were; speech disturbance, bleeding from the ear, visual disturbance, behavior change, amnesia, rhinorrhea, otorrhea, dizziness, unilateral facial weakness, abnormal gait and hearing loss.

GLASGOW COMA SCALE

Changes in the level of consciousness are more important than focal neurological signs and provide an overall index of brain dysfunction and damage. Repeated assessments of the degree of altered consciousness provide a guide to the initial severity of brain damage and to the pattern of recovery. The assessment and reassessment of the consciousness level has been made simple by the use of the Glasgow Coma Scale (GCS) [28].

The Glasgow Coma Scale (GCS) was established by Professor Graham M. Teasdale and Professor Bryan Jennett in 1974. Both were professors of neurosurgery at the University of Glasgow, Scotland[29].

This score is the most widely used scoring system in quantifying level of consciousness following traumatic brain lesions.

The scale is confined to three categories of performance that is; Eye opening (E), Verbal responses (V) and Motor responses (M). A score is given for each test, and the GCS score is calculated by adding the scores given to each test. The maximum score is 15, which means the patient is fully conscious. The minimum score is 3, and usually seen in patients with brain death or those in deep coma. In the grading of head injury GCS score of 14-15 is considered Mild TBI, 9-13 Moderate TBI and 3-8 severe[29]. However, the severity and prognosis are predicted more accurately by also considering CT scan findings and other factors.

The Royal College of Radiologists defines four categories of risk for intracranial injury following head trauma as follows[30]; Low risk: GCS 15/15, no fracture; Medium risk: GCS 15/15, but history of loss of consciousness; High risk: GCS 13-14/15, or GCS 15/15 with a skull fracture; Very high risk: GCS <13/15, or deterioration in clinical condition.

The GCS grading system used in adults is shown in Appendix IIa (page 72).

Morray J. P[31] made an attempt of modifying Glasgow Coma Scale for infants and children, for use in brain injured children. Appendix IIb (page 73) shows the modified GCS.

PATHOLOGY OF HEAD INJURY

SCALP INJURY

A scalp laceration is present in about 40% of patients with head injury who attend hospital. In general blunt injuries cause bruising and sharp objects cause ragged lacerations[28]. A scalp injury can overlie other intracranial pathology, and therefore, requires careful exploration for foreign bodies or underlying skull fractures. Bleeding associated with scalp lacerations can be significant enough to cause hypotension and shock in a small infant. Caput succedanum and cephalohematoma are observed with birth related head trauma. Caput succedanum involves moulding of the neonatal head and crosses the suture lines, whereas cephalohematoma involves subperiosteal bleeding and is limited by the suture lines[5]. On CT scalp lacerations appear as soft tissue defect if large, air within soft tissues or as a hematoma within the scalp[25]. This hematoma is known as a subgaleal hematoma.

SKULL FRACTURE

A skull fracture occurs in 1.5% of patients with head injury. A skull fracture is described by several features; 1).Location: the vault of the cranial cavity; the posterior fossa; or the base of the skull. 2) Shape: linear (fissure) or comminuted into fragments; 3). If the fragments are depressed inwards: 4).If its open or compound[28].

Fractures that contain foreign material or those that involve the paranasal sinuses are termed complicated. Those that lie close to the middle meningeal artery have a high association of extradural hemorrhages[24].

Fractures may be associated with diastases (widening) of one or more sutures, particularly the lambdoid. Simple fractures of the vault are characteristically linear, although they may be irregular, particularly if due to a sharp direct blow. When acute they are typically well defined and appear as fine lines of decreased density. Acute fractures are usually straighter, more angulated, more radiolucent and do not have cortical margins. CT is particularly effective at demonstrating depressed fractures provided bone windows are used[32, 33]. Fractures of the skull base often are manifest on plain films only as fluid and fluid levels representing bleeding or leakage of CSF[34, 35].

TRAUMATIC BRAIN OEDEMA

This is the commonest effect of head trauma. The pathophisiology may be a vascular engorgement or a true oedema; that is, an accumulation of water[28]. The brain oedema can be focal or diffuse[36]. Focal oedema is hypodense in nature on CT in comparison to the rest of the brain. It is limited to the white matter and may result in midline shift and/ or compression of the adjacent cisterns and ventricles. Diffuse oedema is more difficult to appreciate and the only features could be markedly thinned out ventricles and obliteration of the cisternal spaces and sulcal pattern. On MR, an increase in signal intensity on T2 weighted images can be identified[24].

CONCUSSION

The essential feature of a concussion is amnesia for the blow: a patient who can clearly recollect the blow has no concussion. The length of time the patient is amnestic after the blow is called post – traumatic amnesia and it's the best biological marker of the severity of concussion. Patients often have normal findings on neurological examination and the diagnosis is usually a retrospective one. Though the diagnosis is clinical, imaging can help establish the gross condition of the brain[28].

EXTRADURAL (EPIDURAL) HEMATOMA

The extradural hematoma (EDH) is due to the presence of blood between the skull and the outer layer of dura (periosteum). This invariantly results from a tear in one or more of the epidural arteries, usually a branch of the middle meningeal artery. A fracture is seen in about 80% of the cases of EDH[24].

Majority of EDH are unilateral, however, 2%-10% of them are bilateral. On CT acute EDH present as hyperdense homogenous masses with convex well defined margins. The high pressure arterial bleeding causes the dura to bulge convexly. This gives it a lenticular appearance. The EDH is limited to sutures but can cross the midline; as the dura is adherent to the periosteum.EDH cause proportionate mass effect in relation to their size unlike Subdural collections[24, 25]. Occasionally there are areas of hypodensities within an otherwise hyperdense EDH. This usually suggests unclotted blood from an active bleeding site and is known as the swirl sign[34].

SUBDURAL HEMATOMA

The Subdural hematoma (SDH) is located between the dura and arachnoid. The majority are caused by laceration of the bridging cortical veins which is often the result of minor head trauma[35]. The inner surface of a subdural hemorrhage is concave reflecting the easy compressible brain parenchyma[27]. The outer convex margin follows the calvarial shape. With chronicity the subdural collections also become biconvex. Commonly Subdural collections have severe mass effect than extradural ones. Bilateral collections are seen in 33% of acute cases and 20% of subacute ones. Mortality is high in comparison to extradural hemorrhage. Fractures are uncommon in SDH. SDH collections spread all over the hemisphere surface but do not cross the midline.

Acute Subdural bleeds are seen as hyperdense collections with concavo-convex or concave inner margins on CT. acute hemorrhages can have iso- or hypodense attenuation values if the patient is anemic or when there is intermixing with CSF. Acute SDH even when hypodense can be missed on CT, as beam hardening can obscure thin collections. On MR an acute SDH is iso-intense on T1 and extremely hypointense on T2 weighted images. Subdural interhemispheric bleeds are common in children and are secondary to violent head shaking. In 20% of the time both EDH and SDH co-exist[24].

INTRACEREBRAL HEMORRHAGE

Traumatic intracerebral bleeding is usually hemorrhagic contusion. In general, a focal, well-defined, rounded area of abnormal CT density or MRI signal in the brain represents a blood clot, but usually there are multiple areas of altered density or signal indicating blood, surrounded by low density or signal change suggestive of oedema. These often seem to enlarge in the first few days[24]. The most common sites of involvement are the frontal and temporal lobes[37].

SUBARACHNOID HEMORRHAGE

Traumatic subarachnoid hemorrhage (SAH) is observed most frequently in association with a cerebral contusion or hematoma. Although it is usually focal in distribution, it occasionally spreads diffusely throughout the subarachnoid space. Traumatic SAH can be due to: 1) direct pial vessel injury; 2) escape of blood from the contusion site when it is close to the cortical surface or; 3) in associated Intraventricular blood with reflux through the 4th ventricular foramina[24].

On CT, abnormal hyperdensity interdigitating into the sulci and fissure localizes the process to the subarachnoid space. SAH can interfere with cerebral spinal fluid (CSF) resorption at the level of arachnoid granulations and result in communicating hydrocephalus. Additionally, non-communicating hydrocephalus can result if prior Intraventricular hemorrhage resulted in an ependymitis causing aqueductal obstruction[24].

INTRAVENTRICULAR HEMORRHAGE

Blood can reach the Intraventricular space by three mechanisms: shearing/ rupture of subependymal veins, reflux of subarachnoid hemorrhage through the 4th ventricular foramina and contiguous extension of an intracerebral bleed. On CT/ MR, a blood- CSF fluid level can be identified acutely, usually within the occipital horns (due to supine positioning during scanning). Large amounts of intraventricular blood can impede CSF outflow and result in dilatation of individual ventricular segments[24].

CONTUSION

This occurs more commonly in the frontal and temporal lobes. A contusion can either be focal or multiple. It occurs at contact points between the brain and the bony ridges and protuberances of the skull. Injuries occurring at the site of pressure are called 'coup' injuries and those occurring at a remote site are called 'contrecoup' injuries. The former commonly occur in the frontal and temporal lobes. The latter lesions are frequently seen in the lateral anterior temporal lobes and inferior frontal lobe. The temporal lobe contusions are commonly associated with subarachnoid or subdural hemorrhages.

Initially the contusions on CT are hypodense from extensive oedema and necrosis. Petechial hemorrhages in the oedema are seen as hyperdense specks or give an isodense mass effect[24, 27].

DIFFUSE AXONAL INJURY

Diffuse axonal injury results when the shear strains between different parts of the brain cause distortion, stretching and even tearing of the axons in the white matter of the cerebral hemispheres and brainstem. This injury was first described in CT literature by Zimmerman et al[38].

Diffuse axonal injury (DAI) involves predominantly the white matter, including the corpus callosum. It often has a poor prognosis but a characteristic feature of the outcome of head injury is its unpredictability. Most of the damaged white matter appears normal on CT and MRI, though patchy changes in regional mean diffusivity have been reported in diffusion tensor MRI in research settings at present[27]. What may be seen on clinical images are smaller foci of accentuated damage, which are hemorrhagic pathologically but often appear non-hemorrhagic on CT or MRI. They occur in juxtacortical white matter, especially in the parasagittal regions, posterior corpus callosum, low centrum semiovale, and upper midbrain. Diffuse vascular injury is more severe, and there are usually multiple basal hemorrhages. These marker lesions of DAI are of low density on CT and high signal on T2 weighted MRI unless modified by haemorrhage. Brain atrophy is often the outcome. Gradient-echo MRI may help identify older lesions as being of traumatic origin by demonstrating persistent haemosiderin[27].

BRAIN HERNIATION

Cerebral herniations are caused by mechanical displacement of the brain, CSF and blood vessels between the compartments. The types of herniations include; subfalcine, transtentorial, transalar, transdural and tonsillar[27]. Subfalcine herniation results when the cingulate gyrus herniates under the falx. Unilateral descending transtentorial herniation (DTH) is as a result of inferior herniation of the medial temporal lobe through the incisura. When it occurs bilaterally it is termed 'central' herniation. Ascending transtentorial herniation results from upward displacement of the brainstem and the cerebellum through the incisura. Transalar herniation is herniation across the sphenoid wing. Transdural herniation is herniation through a dural and/or skull defect. Tonsillar herniation results from herniation of the cerebellar tonsil into the spinal canal.

Early detection of brain herniation is of major clinical importance in patient management[24].

RATIONALE

Head Injuries are a major cause of morbidity and mortality in our society and the world at large. The brain injured survivor may end up with disability that leaves him/ her in financial difficulties because of increased medical expenses and loss of income. Since head injury appears to affect commonly people in the reproductive age group its impact on the overall economy cannot be overlooked. The morbidity, mortality and disability resulting from head injury could be reduced through improved management of head injuries, a fact that can be achieved by knowing the pattern of head injuries in terms of causative agents and imaging findings. CT is a sensitive primary diagnostic tool in the evaluation of patients with head injury and it plays a critical role in the early detection of intracranial lesions that may require neurosurgical intervention[3].

The effective and efficient use of CT in our setting has benefited the patient in terms of prompt evaluation and management[9]. The aim of the researcher was to determine the current trend of head injury in terms of demographics, aetiology and pattern of findings on MDCT scans at KNH which is a National Public Hospital and Referral Center in East and Central Africa. The study correlated the GCS with the intracranial findings and thereby identified patients with head injury in our set-up who were more likely to benefit from CT scan imaging. No such study has been done previously at this institution. The study was done using a 16 slice helical CT scanner which is more superior to the conventional CT scanners in which Desousa's[5] (1992) and Mashuke's[9] (1997) studies were done. The Multidetector 16 slice scanner has better resolution, faster acquisition of images and low levels of artifacts compared to a conventional CT scanner. In addition this scanner has the capability of offering superior multiplanar reformats which enhance the pick up of traumatic brain lesions[24]. The interval change in the Pattern of head injuries in the last 11 – 16 years was discussed.

OBJECTIVES

BROAD OBJECTIVE

To describe occurrence and pattern of findings of Head Injury on Multidetector Computerized Tomography of the head in patients seen at K.N.H.

SPECIFIC OBJECTIVES

Determine causes of head injury

Determine age and sex distribution of head injury

Determine the presenting complaints of patients with Head Injury

Determine the radiological findings of head injury on C.T. Scan

Correlate Glasgow Coma Scale with Radiological Findings on C.T

Secondary Objective

Establish the time interval from head injury to performing the CT scan study (Scan delay time)

DESIGN AND METHODOLOGY

Study Area

The study was done at Kenyatta National Hospital (KNH), Radiology department.

Study Population

This included all patients with head injury referred from the KNH casualty department for C.T. head.

Study design

A descriptive prospective study was undertaken from July 2008 to October 2008. The patients' clinical summary (age, gender, serial number, GCS and other radiological investigations done) were obtained from the request form and filled into the data collection form (Appendix 1). CT scan findings were reviewed by both the researcher and a consultant Radiologist. These were recorded in the data collection forms.

Materials and Methodology

CT head was performed using a 16 slice spiral CT scanner, Brilliance Model, Serial No.729, manufactured by Phillips in 2007 January.

1) Data Collection tool (Appendix I) page 70

This was a structured questionnaire with seven parts. The first part consisted of the patients' biodata. For the purposes of maintaining confidentiality, each patient had a serial number. The inpatient and/ or outpatient number was recorded for referral purposes. Patients' age in years and gender were recorded. The time and date of injury and CT scanning were also recorded. The second part had causes of injury for instance R.T.A. and falls among others. The third portion had presenting complaints including, loss of consciousness, headache, and nausea and vomiting among others. The fourth part had G.C.S grading into 14-15 (mild), 9-13 (moderate) and ≤ 8 (severe) grades. The fifth part had the CT scan findings recorded, ranging from scalp hematoma to cerebral oedema among other findings. Other imaging studies done were noted in the sixth part of the questionnaire. Associated injuries were recorded in the last part of the data collection tool.

2) Patient Recruitment and Sampling Method

Patients referred for Head CT scan examination at the KNH following head injury between the month of July and October 2008 were recruited for the study. The sampling method used was Consecutive Sampling.

3) CT Scan Reporting

The CT scan images were reviewed by the researcher who formed her opinion. The researcher then reviewed them with a consultant radiologist to generate the final opinion and report. This was done to all the CT scan images for standardization purposes.

4) Inclusion Criteria

This included all patients with head injury referred for a C. T. Scan at Kenyatta National Hospital during the study period. The CT scans were mainly done in the acute period within 24 - 48 hours (85.94%) (Table 7). Few patients (14%) had their scans in the subacute phase (within 48hr – 2weeks).

5) Exclusion Criteria

Head injury patients in which CT scanning was not obtained during the study period.

6) Computerized Tomography Scanning

The patient was placed in supine position within the gantry. A non-opaque head rest support was used. Contiguous axial images were obtained through the brain without intravenous contrast[24]. Slice thickness of 5–10 mm for the supratentorial compartment, and 5 mm or less for the posterior fossa, mainly in an attempt to reduce beam hardening artifact were done. Window widths and levels were set to maximize contrast, between grey and white matter, and were kept constant from patient to patient[19]. Bone, soft tissue and subdural window techniques were done. A subdural window was used in the identification of small SDH. This required the use of intermediate window settings (width 250, level 40) [39]. If significant temporal bone trauma was suspected, 1.5mm thick, high resolution bone algorithm technique through the petrous bones was done. Representative images were selected for printing and forwarded to the physician with the report of the findings. The images were reviewed by the researcher and a consultant radiologist. A few are reproduced in the book as illustrations. (Pages 52-57).

7. SAMPLE SIZE DETERMINATION

The sample size was all the patients attended at Kenyatta National Hospital with head injuries in whom CT scan head was done, within the period of 4 months extending from July 2008 to October 2008. The sample size was determined by the following formula by Fisher et al (1998)[40]. The prevalence rate of traumatic brain injury used was 5 %[7].

$$n = \frac{z^2 \, p \, (1-p)}{d^2}$$

Where n = desired sample size

z = standard normal distribution

p = known prevalence rate for the factor of interest under study

d = the level of significance desired

When this formula is applied at d = 0.05, z = 1.96, and p = 5 % [7]

$$n = \frac{1.96^2 * 0.05(1-0.05)}{0.05^2}$$

n=73

The expected sample size was 73 for the period of 4 months.

For this study a total of 192 patients were recruited within the period of 4months.

8. Data management

Data collection

The principal investigator was assisted by Consultant Radiologists in the X-ray department at Kenyatta National Hospital. Relevant data of the study patients was collected. This included looking at all the images on the computer console as they were saved on the hard disc for some time. The available clinical summary and the C.T. diagnosis were recorded on the data collection tool. With the help of a biostatistician the data was entered into the computer software SPSS and analyzed.

Data analysis

Data analysis was done using Software Programme for Social Science research (SPSS) and Microsoft Excel for Windows. Results are presented in form of frequency distributions and descriptive statistics. The chi-square test for independence was used to test associations. Z tests used for proportional and mean differences were also applied. The level of significance was set at $\alpha=0.05$. Pathology demonstrative images were sampled and presented.

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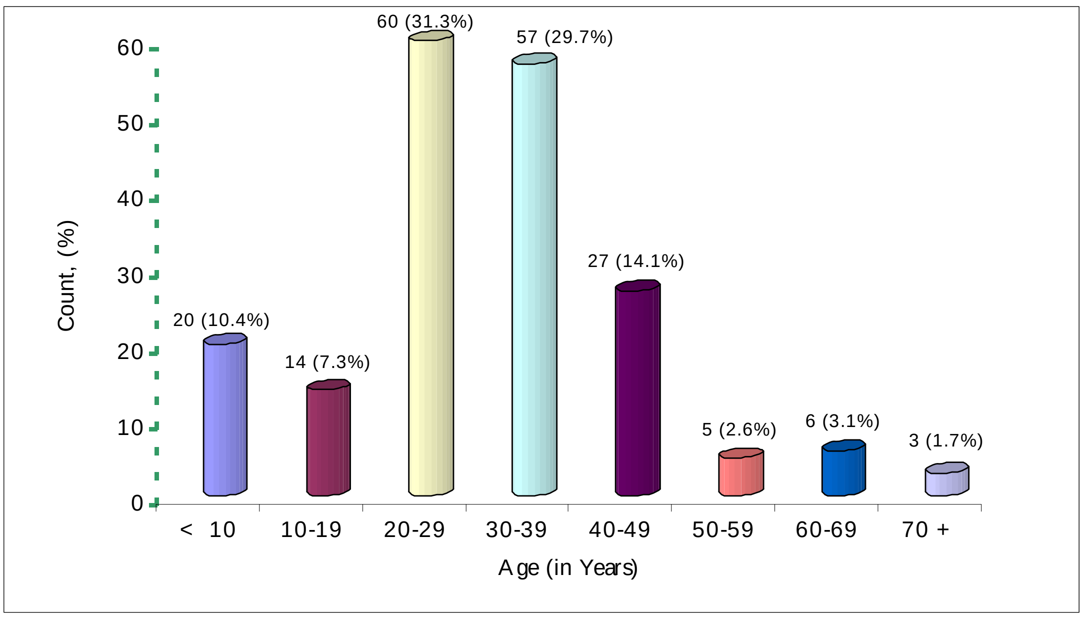
RESULTS

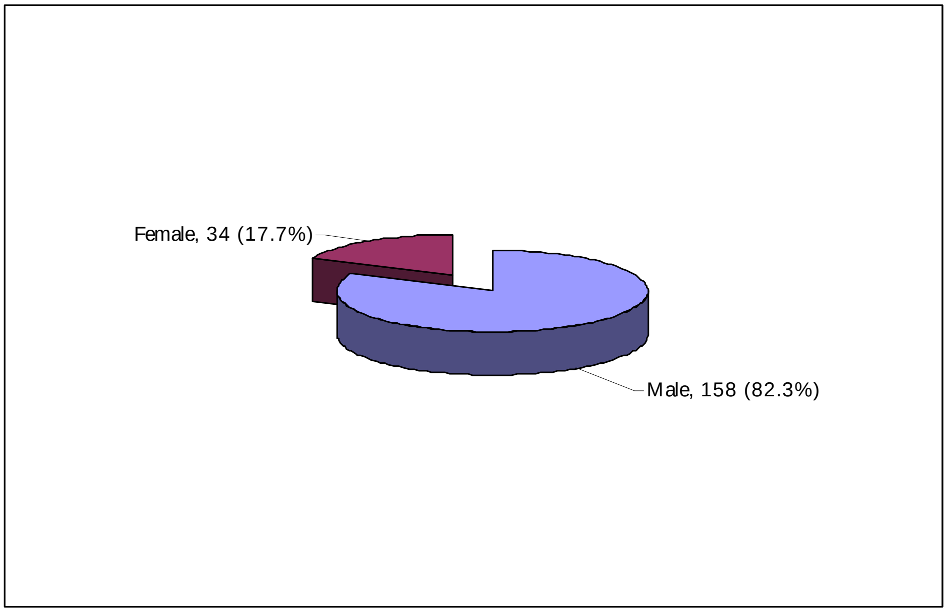
A total of one hundred and ninety two (192) patients with head injury were recruited for the study. A review of these one hundred and ninety two cases is done and results are presented in the form of tables and graphs below. Images with selected pathologies are also presented.

Figure 14: Distribution by Age (n = 192)



The mean age of the study participants was 30.2 years with a median age of 30 years. The ages ranged from 10 month to 85 years.

Figure 15: Distribution by Sex (n = 192)

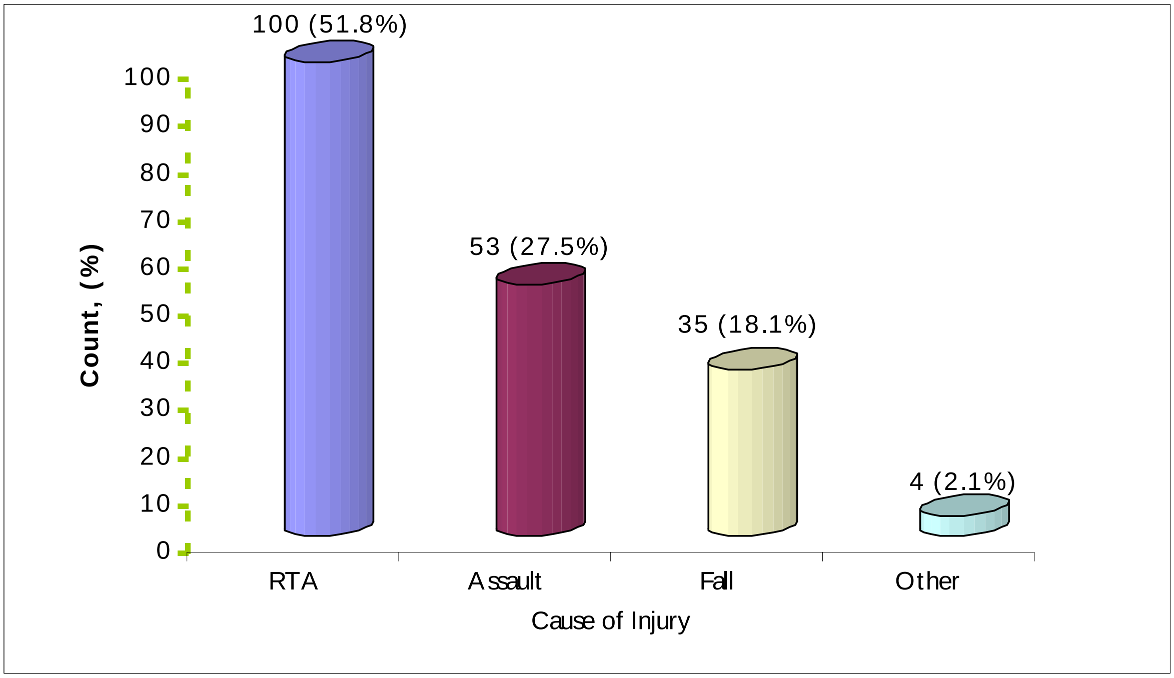


Male: Female = 5:1

Table 1: Distribution of Age by Sex

Age (in Years)	Sex	
	Male, n (%)	Female, n (%)
< 10	11 (7.0)	9 (26.5)
10 – 19	11 (7.0)	3 (8.8)
20-29	49 (39.0)	11 (32.4)
30-39	50 (31.6)	7 (20.6)
40-49	25 (15.8)	2 (5.9)
50-59	4 (2.5)	1 (2.9)
60-69	5 (3.2)	1 (2.9)
70 +	3 (1.9)	0

Figure 16: Cause of Injury (n = 192)



Most causes were by RTA 100 (51.8%) and the least was others which included;

Battered baby (1)

Work related injury (3)

Table 2: Cause of Injury vs. Sex

Cause of Injury	Sex	
	Male	Female
RTA	84	16
Fall	23	12
Assault	48	5
Other	3	1
Total	**158**	**34**

RTA was the commonest cause of head injury among both males and females.

Table 3: Presenting Complaints (n = 192)

Complaints	**Frequency**	**Per cent**
Loss of Consciousness	104	30.95
Headache	56	16.67
Confusion	37	11.01
Drowsiness	17	5.06
Convulsion	14	4.17
Irritability	12	3.57
Nausea	10	2.98
History of a Lucid interval	10	2.98
Vomiting	9	2.67
Rhinorrhea	9	2.67
Otorrhea	6	1.79
Dizziness	6	1.79
Bleeding from ears	6	1.79
Other	40	11.90
Total	**336**	**100.00**

Others included;

Epistaxis

Aphasia

Hemiparesis

Restlessness

Staggering gait

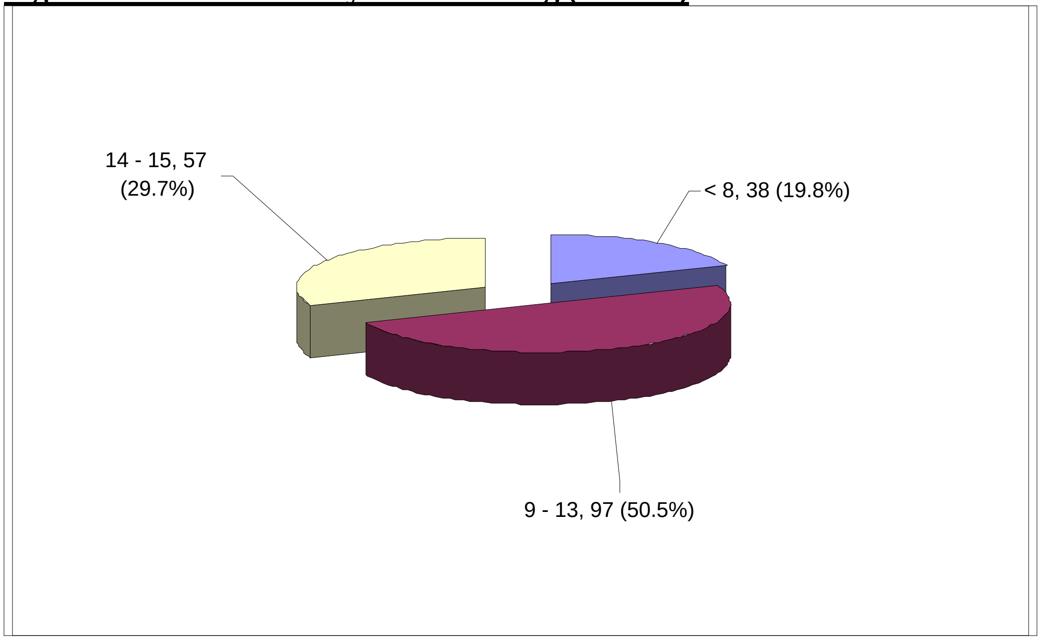
144patients (72.9%) had combination of presenting complaints. The commonest combinations among 100 sampled patients were;

Table 4:combination of presenting symptoms

Combination of symptoms	Frequency
Loss of consciousness + Headache	14
Headache + Confusion	12
Loss of consciousness + Confusion	10
Loss of consciousness + Irritability	8
Loss of consciousness+ Drowsiness	8
Loss of consciousness + lucid interval	8
Headache + Confusion + lucid interval	8
Loss of consciousness + Irritability+ drowsiness	7
Headache + other	7
Headache + bleeding from ears	5
Loss of consciousness + Vomiting	5
Convulsion + Other	4
Confusion + Other	4
Total	100

Two patients had a combination of four symptoms. These were; headache, confusion, Rhinorrhea and a history of lucid interval.

Figure 17: Distribution by GSC Grading (n = 192)



Most patients in the study had a GCS of 9-13 at 50.5%.

Table 5: Distribution of GCS Grading by Age

Grading	Mean	Median	Range
• 14-15	28.8	28.0	5 – 76
• 9 – 13	29.9	29.5	0.8 – 85.0
• ≤ 8	33.3	32.0	1.0 - 65.0

Table 6: GCS GRADING VERSUS CAUSE OF INJURY

GCS	RTA	FALL	ASSAULT	OTHER	TOTAL
14-15	23	9	25	0	**57**
9-13	51	23	20	3	**97**
<=8	24	3	8	1	**38**
TOTAL	**100**	**35**	**53**	**4**	**192**

Table 7: scan delay time

Time from injury to CT scan	**frequency**	**percentage**
0-6hr	96	50
6-12hr	50	26.04
12-24hr	9	4.7
24-48hr	10	5.2
>48hr	27	14.06
	192	**100**

Most patients in this study had a CT scan done within the first 6hours after injury.

Table 8: CT SCAN FINDINGS

Variable	**Frequency**	**Percentage (%)**
Scalp injury / haematoma	65	9.21
Linear Skull Fracture	64	9.07
Focal cerebral oedema	44	6.23
Diffuse cerebral oedema	61	8.64
Depressed Skull fracture	41	5.81
Base of Skull Fracture	48	6.80
Epidural Haematoma(EDH)	32	4.53
Subdural Haematoma(SDH)	28	3.97
Intracerebral Haematoma	50	7.08
Contusion	58	8.22
Midline Shift	44	6.23
Hemosinus	54	7.65
Subarachnoid hemorrhage	35	4.96
Normal CT	23	3.26
Pneumocephalus	23	3.26
Brain herniation	23	3.26
Intraventricular Hemorrhage	9	1.27
Diffuse Axonal Injury(DAI)	4	0.57
Total	**706**	**100**

Other CT scan findings not related to head injury included:

Sinusitis (30)

Polyps within the sinuses (4)

Brain atrophy (6)

Cerebral infarcts (2)

Arachnoid cyst (1)

Table 9: COMBINATION OF CT FINDINGS VERSUS GCS GRADING

Count

		grading			Total
		14 - 15	9 - 13	<8	
No. of COMBINATIONS	2.00	20	19	3	42
	3.00	10	16	4	30
	4.00	5	15	4	24
	5.00	4	12	3	19
	6.00	1	10	7	18
	7.00	3	9	5	17
	8.00	1	4	3	8
	9.00	0	4	3	7
	10.00	0	0	1	1
	11.00	0	0	1	1
	12.00	0	1	0	1
Total		44	90	35	169

All patients had a combination of CT scan findings. The majority, 42 patients had two combinations. 20 of these had a GCS score of 14-15. One patient had the most combinations at 12. This patient fell in the 9-13 GCS scale.

The commonest combination was between Subgaleal hematoma and cerebral oedema at 21.8%.

Table 10: Scalp/Subgaleal Hematoma (n = 65)

Location	Frequency	percentage
Frontal	29	30.53
Parietal	52	54.74
Temporal	9	9.47
Occipital	5	5.26
	95	**100.00**

Table 11: Linear Skull Fracture (n=64)

Location	Frequency	percentage
Frontal	31	29.52
Parietal	37	35.24
Temporal	24	22.86
Occipital	13	12.38
	105	**100.00**

Table 12: Depressed skull Fracture (n=41)

Location	Frequency	percentage
Frontal	23	39.66
Parietal	26	44.83
Temporal	5	8.62
Occipital	4	6.90
	58	**100.00**

Table 13: Epidural hematoma (n=32)

Location	Frequency	percentage
Frontal	20	37.74
Parietal	20	37.74
Temporal	9	16.98
Occipital	3	5.66
Cerebellar	1	1.87
Frontal	20	37.74
	73	**100.00**

Table 14: Subdural hematoma (n=28)

Location	Frequency	percentage
Frontal	20	37.04
Parietal	19	35.19
Temporal	8	14.81
Occipital	6	11.11
Cerebellar	1	1.85
	54	**100.00**

Table 15: Intracerebral haemorrhage (n=50)

Location	Frequency	percentage
Frontal	31	36.47
Parietal	28	32.94
Temporal	14	16.47
Occipital	8	9.41
Cerebellar	1	1.18
Pons	1	1.18
Midbrain	2	2.35
Medulla	0	0
	85	**100**

Table 16: Contusion(n=58)

Location	Frequency	percentage
Frontal	34	44.16
Parietal	22	28.57
Temporal	9	11.69
Occipital	9	11.69
Cerebellar	1	1.30
Pons	1	1.30
Midbrain	1	1.30
Medulla	0	0
	77	**100.00**

Table 17: Intraventricular H. (n=9)

Location	Frequency	percentage
Lateral Ventricle	7	58.33
Third Ventricle	2	16.67
Fourth Ventricle	3	25.00
	12	**100.00**

Table 18: Mid Line Shift (n=44)

	Frequency	percentage
RT-LT	24	54.55
LT-RT	20	45.45
	44	**100.00**

Table 19: Brain Herniation (23)

Type	Frequency	percentage
Subfalcine	22	95.65
Uncal	1	4.35
	23	**100.00**

Table 20: Cerebral Oedema(n=105)

	Frequency	percentage
Diffuse cerebral oedema	61	58.10
Focal cerebral oedema	44	41.90
	105	**100.00**

Table 21: Hemosinus (n=54)

Location	Frequency	percentage
Frontal	9	9.57
Ethmoid	23	24.47
Maxillary	18	19.15
Sphenoid	31	32.98
Mastoid.	13	13.83
	94	**100.00**

Table 22: Association between Linear Skull Fractures vs. Epidural Hematoma

Epidural hematoma	Linear		P-value
	Yes	No	
Yes	24 (37.5)	120 (93.8)	<0.001
No	40 (62.5)	8 (6.2)	

Table 23: Association between linear skull Fractures Vs SDH

	Linear fracture frequency			
	no	yes	total	p- value
SDH freq. no	115	49	169	0.025
yes	13	15	28	
	128	64	192	

Table 24:Association between depressed skull fracture versus EDH

	Depressed fracture frequency			
	no	**yes**	**total**	**p-value**
EDH freq. No	130	30	160	**0.045**
yes	21	11	32	
total	**151**	**41**	**192**	

Table 25: Association between Depressed skull fracture vs SDH

	Depressed fracture frequency			
	No	Yes	Total	p-value
SDH freq. No	128	36	164	0.811
Yes	23	5	28	
total	151	41	192	

All p- values less than 0.05 were statistically significant.

Table 26 :CT Scan Findings versus Cause of Injury.

	CAUSE OF INJURY		
FINDINGS	**RTA**	**FALL**	**ASSAULT**
Cerebral Oedema	64	13	26
Subgaleal/Scalp Hematoma	35	6	24
Contusion	31	5	20
Linear Skull Fracture	34	10	19
Intracerebral haemorrhage	27	7	15
Base of Skull Fracture	30	7	10
Mid Line Shift	31	3	9
Depressed skull Fracture	21	3	17
Subarachnoid	22	6	5
Epidural hematoma	24	1	7
Subdural hematoma	20	5	3
Brain Herniation	16	0	7
Pneumocephalus	9	7	7
Intraventricular Hemorrhage	7	0	2
Hemosinus	32	8	13
Diffuse Axonal Injury	4	0	0
Normal CT Scan Finding	7	9	7

Table 27: Sex vs. finding

	Sex		
Findings	Male	Female	p-value
Diffuse Cerebral Oedema	49	12	0.627
Focal cerebral oedema	37	7	0.722
Subgaleal/Scalp Hematoma	58	7	0.072
Contusion	52	6	0.079
Linear Skull Fracture	55	9	0.349
Intracerebral haemorrhage	44	6	0.219
Base of Skull Fracture	41	7	0.513
Mid Line Shift	35	8	0.861
Depressed skull Fracture	37	4	0.133
Subarachnoid	23	5	0.982
Epidural hematoma	29	3	0.176
Subdural hematoma	23	5	0.982
Pneumocephalus	14	9	0.560
Hemosinus	47	7	0.281
Brain Herniation	21	2	0.227

Table 28: Association between GCS Grading and Findings

	Grading			
Findings	14 to 15	9 to 13	< 8	p-value
Diffuse Cerebral Oedema	9	33	19	<0.001
Focal Cerebral oedema	7	26	11	0.040
Subgaleal/Scalp Hematoma	19	32	14	0.761
Contusion	14	27	17	0.039
Linear Skull Fracture	11	37	16	0.01
Intracerebral haemorrhage	4	29	17	<0.001
Base of Skull Fracture	11	25	12	0.245
Mid Line Shift	1	25	17	<0.001
Depressed skull Fracture	10	22	9	0.546
Subarachnoid	3	15	10	0.008
Epidural hematoma	2	22	8	0.004
Subdural hematoma	3	15	10	0.008
Hemosinus	13	23	18	0.005
Pneumocephalus	8	14	1	0.164
Brain Herniation	1	15	7	0.010
Diffuse Axonal Injury	0	0	4	0.005
Intraventricular Hemorrhage	0	4	5	0.009
Normal CT scan	16	6	1	0.023

A p-value < 0.05 is statistically significant.

Table 29. Age vs. findings

	Age	
Findings	Mean (SE)	p-value
Diffuse Cerebral Oedema	28.7 (1.7)	0.337
Focal Cerebral oedema	33.6(2.6)	0.078
Subgaleal/Scalp Hematoma	32.3 (1.6)	0.16
Contusion	32.2 (1.6)	0.22
Linear Skull Fracture	30.1 (1.5)	0.941
Intracerebral haemorrhage	33.0 (2.0)	0.125
Base of Skull Fracture	31.7 (1.5)	0.419
Mid Line Shift	32.5 (2.2)	0.245
Depressed skull Fracture	32.8 (2.5)	0.197
Subarachnoid	34.4 (3.0)	0.106
Epidural hematoma	31.5 (2.0)	0.593
Subdural hematoma	34.4 (3.0)	0.106
Pneumocephalus	24.0(2.9)	0.034
Hemosinus	32.3(1.4)	0.227
Brain Herniation	33.6 (2.3)	0.241

A p-value < 0.05 is statistically significant.

Table 30: Associated Injuries

Injury	**Frequency**	**Per cent**
Neck injuries	4	7.84
Abdominal injuries	2	3.92
Spine injuries	6	11.76
Cord injuries	1	1.96
Chest injuries	21	41.18
Upper limb fracture	7	13.73
Lower limb fractures	10	19.60
Other	0	0
Total	**51**	**100**

Majority of patients with associated injuries had chest injuries at 41.2%

Table 31: Associated Injuries Versus Cause of Injury

Injury	**RTA**	**FALL**	**ASSAULT**	**OTHER**
Neck	1	0	3	0
Abdomen	1	0	1	0
Spine	4	0	2	0
Cord	1	0	0	0
Chest	12	0	9	0
Upper limb fracture	1	0	3	3
Lower Limb Fracture	4	1	3	2
Total	**24**	**1**	**21**	**5**

Most associated injuries were found in patients who had head injury as a result of road traffic accidents.

Table 32 :ASSOCIATED INJURIES VERSUS GCS GRADING

Injury	**14-15**	**13-9**	**<=8**
Neck	2	0	2
Abdomen	1	1	0
Spine	3	0	3
Cord	0	0	1
Chest	5	6	10
Upper limb fracture	3	3	1
Lower Limb Fracture	4	4	2
Total	**18(35.3%)**	**14(27.4%)**	**19(37.2%)**

Associated injuries were more common in patients with a GCS of < 8.

These were 19 patients (37.2%).

Majority had chest injuries.

Table 33 :FACIAL FRACTURES

Facial fracture	**frequency**	**percentage**
Mandible	8	33.3
Maxillary	4	16.7
Zygoma	5	20.8
Nasal bone	4	16.7
Blow out fracture of the orbit	3	12.5
Total	**24**	**100**

The commonest facial bone fracture was the mandible at 33.3%.

SELECTED CT SCAN IMAGES WITH DEMONSTRATIVE PATHOLOGIES

Figure 18

Figure 19

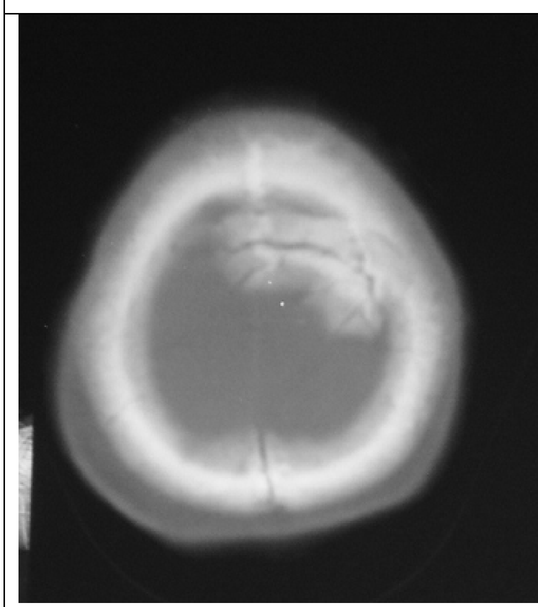
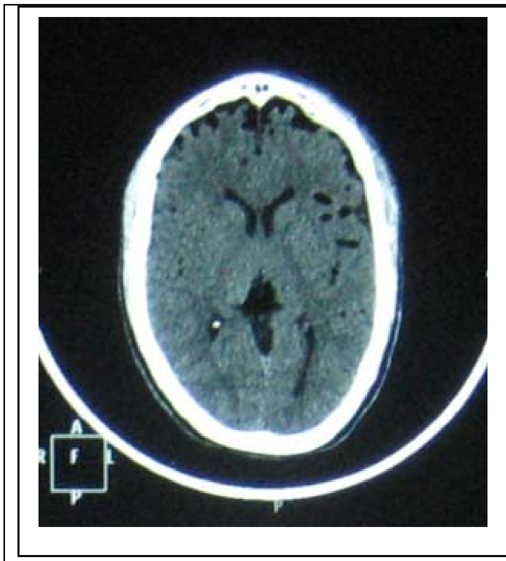
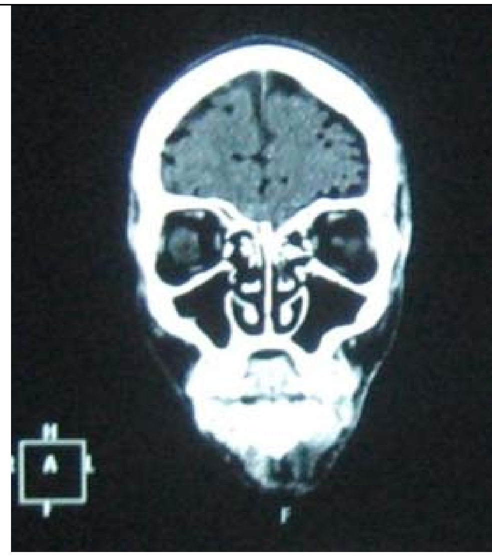
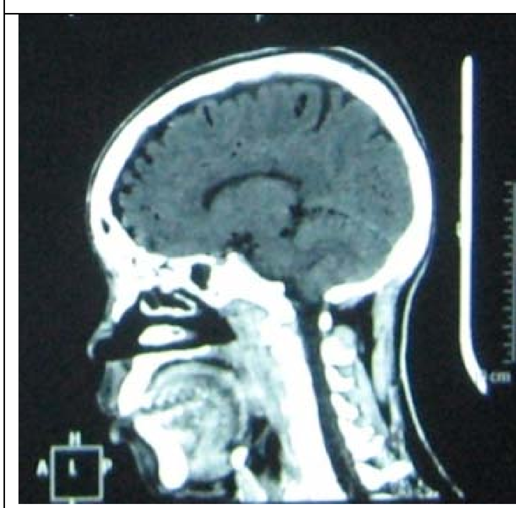
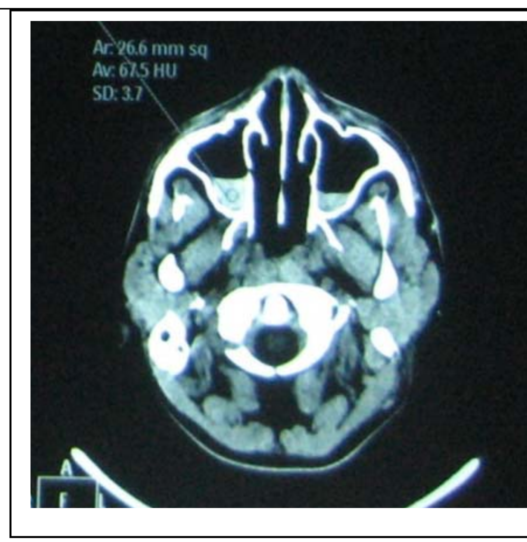


Figure 20

Figure 18
reformatted coronal CT scan in bone window demonstrating a depressed frontal bone fracture

Figure 19
3D reconstruction with depressed stellate fracture of the frontal bone

Figure 20
Axial CT scan in bone window demonstrating a linear fracture with a Subgaleal hematoma

 Figure 21	 Figure 22	Figures 21, 22 and 23 Axial CT scan with Coronal and Sagittal reformats demonstrating Pneumocephalus
 Figure 23	 Figure 24	Figure 24 Axial CT scan at the base of skull of same patient as in figures 21, 22 and 23 demonstrating bilateral maxillary hemosinus

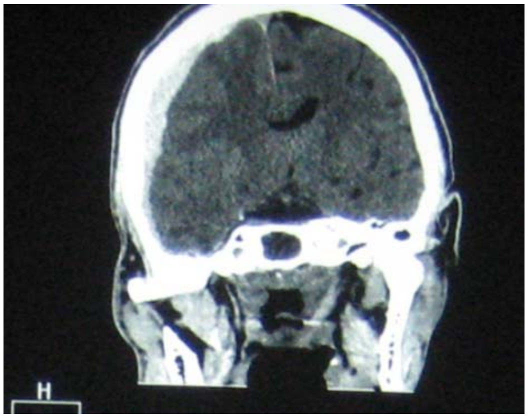


Figure 25

Figure 26

Figure 25 reformatted coronal CT scan image showing a right parietal acute SDH with mass effect as evidenced by compression of the ipsilateral lateral ventricle.

Figure 26 reformatted sagittal CT scan of same patient as in figure VII demonstrating SDH

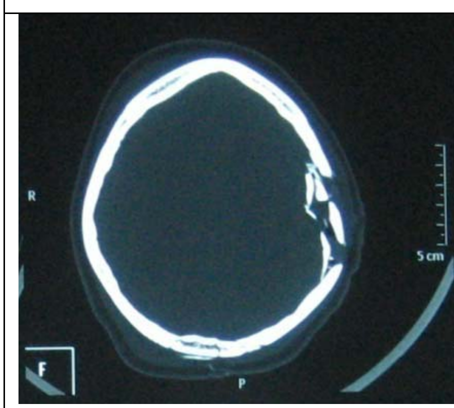


Figure 27

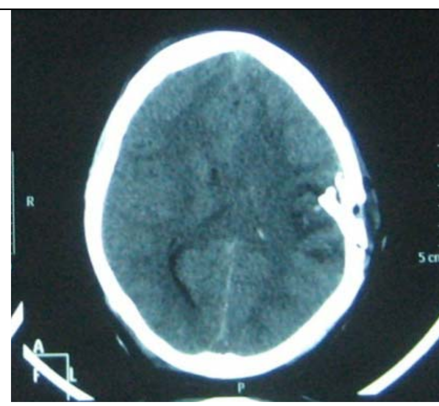
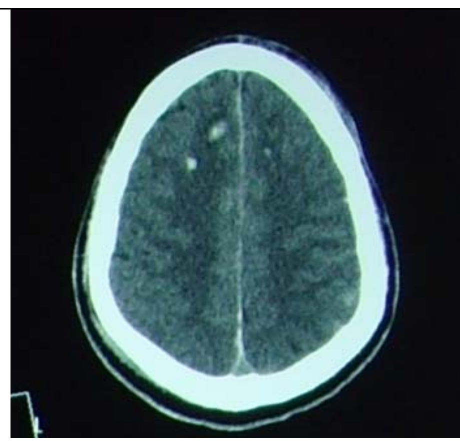
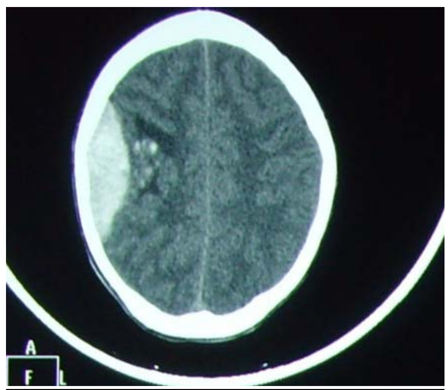
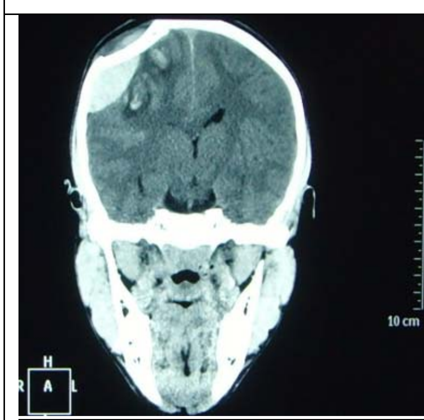


Figure 28

Axial CT scan images in bone window Figure 27 and Brain window Figure 28. Demonstrating a left parietal comminuted fracture.

		Figures 29, 30 and 31 Axial CT scan with coronal and sagittal reformats demonstrating a right frontal acute intracerebral hematoma associated with a depressed skull fracture + left frontal acute subdural hematoma (figure 30)
Figure 29	Figure 30	
		Figure 32 Axial CT demonstrating diffuse axonal injury
Figure 31	Figure 32	

		Figures 33, 34 and 35 Axial, coronal and sagittal CT scans demonstrating an acute right midbrain hemorrhage. This is also known as a duret hemorrhage.
Figure 33	Figure 34	
		
Figure 35	Figure 36	
		Figures 36, 37 and 38 Axial, coronal and sagittal CT scans demonstrating a right acute Epidural hematoma with an associated Subgaleal hematoma and a depressed skull fracture.
Figure 37	Figure 38	

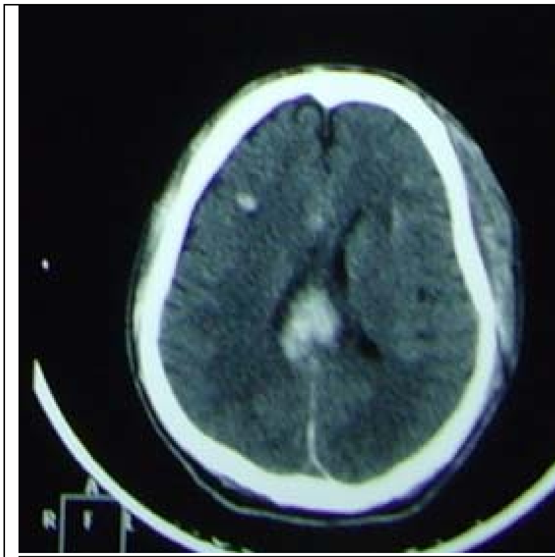


Figure 39

Figure 40

Figure 41

Figures 39, 40 and 41

Axial, coronal and sagittal CT scans demonstrating subarachnoid hemorrhage.

DISCUSSION

The commonest age group of patients scanned in this study was found to be the 20-29 year age group which accounted for 31.3% of the study population (Figure 33). The next common age group was the 30 -39 years. At the extremes of age fewer patients were found. The peak age in this study was 30.2 years which correlated with peak ages of studies done by De Sousa5 (1992), Mwangombe[12] (1979) and M. Naseri and co-authors[20] (2005).

Out of a total of 192 patients included in this study 158 (82.3%) were male and 34 (17.7%) were females (Figure 15). The male to female ratio in this study was 5:1. Previous studies have demonstrated a similar male preponderance[5, 12, 15]. The possible reasons for this gender bias could be attributed to differences in lifestyle and nature of work between the two sexes. Males tend to form a larger population of drivers and passengers on the roads. They are also more predisposed to assault in comparison to their female counterparts.

Road Traffic Accidents (RTA) accounted for the majority of head trauma cases (Figure 16). A total of 100 (51.8%) suffered head trauma following RTA. This was followed by assault at 53 (27.5%) and fall at 35 (18.1%). The least contribution was work related injuries (3) and child abuse (1). Similar results were also noted in previous studies[5, 12,13] indicating that the trend of causative factors in head trauma has tended to be the same over the years . The high incidence of head injury from road traffic accidents in this study could be attributed to the high number of motor vehicles on our roads and the tendencies of the drivers to ignore basic traffic rules and over-speeding. Passengers may be blamed for failing to observe safety measures such as putting on their safety belts. The low incidence of work related head injury may be a pointer to work safety measures observed by both the employers and employees.

In this study the commonest presentation of patients was loss of consciousness. This was found in 104 patients (31%). This was followed by headache (17%) and confusion (11%). 14 patients (4.2%) presented with convulsions. The frequency of various presenting symptoms is shown in table 3. 73% of patients had a combination of presenting complaints. Atleast 100 patients had 2 or 3 presenting complaints. Table 4 shows the various combinations and their frequencies. Otorrhea, Rhinorrhea and Bleeding from the ears were the common signs where base of skull fractures were suspected. Similar results were found in studies done earlier[5]. There tended to be a higher diagnostic yield in patients presenting with a combination of symptoms than those presenting with only one symptom. This was higher in patients who had a combination with atleast loss of consciousness as one of the variables. This was also seen in patients presenting with mild head injury.

In this study most patients had moderate brain injury (50%). Mild and severe brain injury accounted for 31.1% and 19% (figure 17). De Sousa[5] and M. Naisseri[20] found most of their patients as having mild brain injury at 56.8% and 75% respectively. This difference could be attributed to the type of the institution; private versus public and the availability of medical covers as well as to the screening method used prior to requesting for CT study.

There was a significant reduction in scan delay time. 50% of patients were scanned within 6 hours of their injuries (table 7). This was a significant improvement from an earlier study done in which most patients were scanned within 48hours[5].

Only 3.3% of patients had normal CT scan findings at KNH. In an earlier study done at a private facility[5] in Kenya, 25% of patients had normal CT scan findings. Among the 23(3.3%) patients with normal scan findings in this study 16 had a GCS of 14-15, 6 had a GCS of 9-13 while only 1 had a GCS of <= 8.

The commonest CT scan finding in this study was scalp/subgaleal hematoma with the commonest location being parietal region. Kelly C. and Co-authors[18] (2002) had similar findings.

Fractures of the skull vault were among common findings in this study. 9.53% patients had linear fractures while 6.11% had depressed skull fractures(table 8). The commonest site for linear skull fractures was the parietal bone (table 11). The commonest sites for depressed skull fractures were the parietal bone and frontal bone (table 12). Use of 3D reconstruction enhanced the demonstration of depressed skull fracture especially the stellate ones (figure 19). Earlier studies done had a similar pattern of distribution of fracture sites[5, 15].

In this study 7.15% of patients had base of the skull fractures (table 8). The commonest presenting complaints among these patients were Rhinorrhea, otorrhea and bleeding from ears. Most of these patients had moderate head injury (table 28). An earlier study found 4.4% of patients to have base of skull fractures[5]. Thin slices and a bone algorithm were used in the petrous ridge region whenever the clinical suspicion of base of skull fracture was made. The multiplanar reformats were additionally helpful in the diagnosis of base of skull fractures.
12.5% of patients had associated facial bone fractures. The commonest affected bones were the mandible and zygoma (table 33). Most of these were associated with assault.

The frequency of different intracranial pathologies encountered during the study is demonstrated table 8. The relative frequencies of various CT scan findings for the different causes of injury, sex GCS groups and age are demonstrated in tables 26, 27, 28 and 29 respectively.

23 scans (3.42%) were found to be completely normal. Among the normal scan findings only one fell in the severe head injury group (GCS <=8). Despite being normal a high

index of suspicion of diffuse axonal injury(DAI) should be considered and the patient ought to be referred for Magnetic Resonance Imaging which is better at evaluating DAI[23].

Cerebral oedema was the commonest intracranial finding at 15.54%. These included both focal and diffuse cerebral oedema[36]. However, when considered separately diffuse cerebral oedema accounted for 8.64% while focal cerebral oedema accounted for 6.23% of all the CT scan findings (table 8). Most patients had moderate head injury (table 28). A study done earlier had fewer patients having cerebral oedema at 8.8%[5]. The difference in findings could be attributed to the different health institutions in which the studies were done; public versus private and the fact that more patients in this study had more severer forms of head injury.

Intracranial hematomas were categorized into three main groups. These were; Intracerebral, Epidural (EDH) and Subdural (SDH) hematomas.
7.45% of patients had intracerebral hematomas with the commonest site being the frontal lobe (tables 8, 15). Alissa.A[15] had 5.6% of patients with this finding.

Epidural hematoma (Figure 37) was found in 4.76% of patients (table 8). The commonest locations were parietal and frontal lobes (table 13). Earlier studies had more patients with this finding[5, 15]. 25 and 14 patients had coexisting EDH with linear and depressed skull fractures respectively (tables 22, 24).

Subdural hematomas (Figure 25) were encountered 4.17% of patients (table 8). Similar findings were noted by Alissa[15]. The commonest location was the frontal lobe followed by the parietal lobe (table 13). 15 and 5 patients had coexisting SDH with linear and depressed skull fractures respectively (tables 23, 25).
Intracranial hematomas (Figure 29) were commonly seen in patients with moderate to severe head injury by GCS grading (table 28).

Cerebral contusions were encountered in 58patients. This accounted for 8.64% patients (table 8). The commonest location was the frontal lobe at 44% (table 16). Most of the patients had moderate head (table 28). Earlier studies done had contusion injury as their commonest finding[5, 20].

Mass effect was demonstrated by shift of midline structures and also by brain herniation. A shift of the midline was seen in 44patients (6.56%). 24(55%) had a shift from right to the left and 20(45%) (Tables 8, 18) had a shift from the left to the right side. This mainly depended on the presence of intracranial hematoma and cerebral oedema. Midline shift was associated with ventricular compression on the ipsilateral side and dilatation on the contralateral side. It was commonly associated with moderate and severe head injury (table 28). Only 1(one) patient with midline shift had mild head injury. An earlier study showed midline shift in 17.5% of patients[5].

Brain herniations were seen in 23patients (3.42%). Subfalcine herniation was the frequently encountered type at 96 % (table 19). Most of the patients had moderate head injury followed closely by severe head injury (table 28). Only 1(one) patient with brain herniation had mild head injury. Coronal reconstructions were helpful in making a diagnosis of subfalcine herniations. Majority of the patients had coexisting cerebral oedema.

Pneumocephalus (Figures 22, 22, 23) was seen in 23 patients (3.42%). It was commonly associated with fractures extending to involve paranasal sinuses. 9 cases were as a result of RTA while 7 were due to fall and 7 due to assault. Most of these patients had moderate head injury. 17 patients had coexisting scalp/Subgaleal hematoma while 16 patients had coexisting cerebral oedema. Skull base fractures occurred in 15 of these patients. Similar findings were seen in an earlier study[5] . A study done in Iran had more patients with pneumocephalus at 12.1%[20].

Hemosinus (Figure 24) was seen in 54 patients. This accounted for 7.65% of patients. Majority had moderate head injury. The commonly affected sinus was the sphenoid (Table 21). It commonly coexisted with base of skull fractures(37), cerebral oedema(37) and linear skull fractures (28). This finding did not exist in earlier studies done[5, 18].

Subarachnoid hemorrhage (figures 40, 41, 42) was seen in 35 patients. This accounted for 4.96% of the study population. Most patients had moderate head injury and severe head injury (table 27). Only 3 patients had mild head injury. It commonly coexisted with cerebral oedema (28 patients) and linear skull fractures (16 patients). An earlier study had close similar findings[5].

The least common CT scan findings were intraventricular hemorrhages and diffuse axonal injury. 9 patients had Intraventricular hemorrhages, this accounted for 1.27% of patients. Similar findings were noted in earlier studies[5, 21]. 58%, 17% and 25% of the Intraventricular hemorrhages were found in the lateral, third and fourth ventricles respectively (table 17). Some patients had involvement of more than one ventricle involved. Among this group 0, 4 and 5 patients had a GCS score of 14-15, 9-13 and <=8 respectively. This indicates that Intraventricular hemorrhage is more associated with severe forms of head injury.

Diffuse axonal injury (Figure 33) was seen in 4 patients in the study population. This accounted for 0.57%. They were all as a result of road traffic accidents. All four patients had severe head injury. The pick up of diffuse axonal injury was greatly enhanced by the use Multidetector CT. This correlated well with a study done by David Gadda and Co-authors[23].

There were some incidental scan findings observed in this study. The commonest finding was sinusitis (30 patients) with the commonest finding being the maxillary sinus. Other findings included brain atrophy(6 patients), polyps within the sinuses(4 patients), brain infarcts(2patients), leukoencephalomalacia(1patient) and an arachnoid cyst(1patient).

61 patients had skull radiographs done. 26 patients had RTA, 10 had falls, 23 had assault , 1 had work related injury and 1 had child abuse. Among this group 23, 30

and 8 patients had a GCS score of 14-15, 9-13 and <=8 respectively. This showed a good trend among clinicians since patients with severe head injury tended to have CT scans done as the primary investigation rather than plain skull radiography.

51 patients had associated injuries. Most of them were as a result of road traffic accidents. Chest injuries were the most common associated injuries. Majority of the patients with associated injuries had severe head injuries (tables 31, 32).

This study found similar trends in head injury as regards to causes of injury and sex distribution with studies done by De Sousa[5] (16years ago) and Mwangombe[12](27years ago). The commonest cause of head injury was RTA and males were significantly affected compared to their female counterparts. This study had more patients with moderate head injury unlike De Sousa's[5] which had more of mild head trauma. There was increased pick up of CT scan pathologies due to more variables included in this study. These included scalp hematoma, brain herniation and Hemosinus. MDCT enhanced the diagnosis of diffuse axonal injury which was not picked in De Sousa's[5] study.

CONCLUSIONS

The introduction of a Multidetector CT (MDCT) scanner in Kenyatta National Hospital has assisted in the adequate diagnosis of head injury and hence prompt management of these patients.

The multiplanar reformats were helpful in making conclusive diagnoses especially in brain herniations and subtle subdural hematomas.

3D reconstructions were helpful in the depiction of depressed skull fractures especially the ones which were stellate.

MDCT was found to be an accurate diagnostic tool in the evaluation of head trauma, and could enable the diagnosis of most of the subtle findings seen in Diffuse axonal injury.

The reduction in the scan delay time resulted in imaging more patients which greatly assisted the clinicians in instituting early appropriate therapy. The acquisitions of the scans within a split of a second ensured that there was substantial reduction of motion artifacts from the severely injured patients.

RECOMMENDATIONS

The use of Glasgow Coma Scale and writing of adequate clinical history cannot be overemphasized. The GCS was a predictor of CT scan findings severity. For the total evaluation of the CT scan in cases of head injury the patient's clinical summary and GCS grading are very important. It is therefore recommended that the use of Glasgow Coma Scale should be continued.

The commonest cause of head injury in this study was found to be Road Traffic Accidents. These means that the hospital's accident and emergency department needs to be adequately equipped to manage Head injured patients right from the site of the RTA. To further improve on this it is recommended that KNH should acquire a separate MDCT machine to strictly cater for this department.

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APPENDIX I

QUESTIONNAIRE

1. PATIENT'S BIODATA

Serial no ………………….

IP/OP NO …………………

Age in years………………..

Gender	Male ………..	Female…………
Time and date of injury	Time ………..	Date…………….
Time and date of scanning	Time ………..	Date……………

2. CAUSE OF INJURY

- ☐ R.T.A.
- ☐ Fall
- ☐ Assault
- ☐ Gun shot
- ☐ Others_________

3. PRESENTING COMPLAINTS

- ☐ Loss of consciousness
- ☐ Headache
- ☐ Nausea and vomiting
- ☐ Rhinorrhea
- ☐ Otorrhea
- ☐ History of a lucid interval
- ☐ Other________

4. G.C.S. GRADING

- ☐ 14 – 15
- ☐ 9- 13
- ☐ < 8

5. C.T. SCAN FINDINGS

- ☐ Scalp Hematoma
- ☐ Skull Fracture
- ☐ Basillar skull fracture
- ☐ Epidural hematoma
- ☐ Subdural hematoma
- ☐ Intracerebral hemorrhage
- ☐ Intraventricular hemorrhage
- ☐ Subarachnoid hemorrhage
- ☐ Diffuse axonal injury
- ☐ Pneumocephalus
- ☐ Brain Herniation
- ☐ Cerebral Oedema
- ☐ Hemosinus
- ☐ Other findings

  ____

6. OTHER IMAGING STUDIES (if available)

- ☐ Skull Radiographs
- ☐ Cranial Ultrasound
- ☐ MRI Scans
- ☐ None

7. ASSOCIATED INJURIES

- ☐ Neck injuries
- ☐ Abdominal injuries
- ☐ Spine injuries
- ☐ Cord injuries
- ☐ Chest injuries
- ☐ Upper limb fractures
- ☐ Lower limb fractures
- ☐ Others___________________
- ☐ None

APPENDIX IIa

GLASGOW COMA SCALE Adults

Category	**Score**
Eye – opening (E)	
Spontaneous	4
To Speech	3
To Pain	2
Nil	1
Verbal Response (V)	
Oriented	5
Confused conversation	4
Inappropriate words	3
Incomprehensible words	2
Nil	1
Best Motor Response (M)	
Obeys	6
Localizes	5
Withdraws	4
Abnormal flexion	3
Extensor response	2
Nil	1
Coma Score = E + V + M	
Minimum	**3**
Maximum	**15**

APPENDIX IIb **Modified GCS for Infants and Children**

Area Assessed	Infants	Children	Score
Eye Opening	Open spontaneously	Open spontaneously	4
	Open in response to verbal stimuli	Open in response to verbal stimuli	3
	Open in response to pain only	Open in response to pain only	2
	No response	No response	1
Verbal response	Coos and babbles	Oriented, appropriate	5
	Irritable cries	Confused	4
	Cries in response to pain	Inappropriate words	3
	Moans in response to pain	Incomprehensible words or nonspecific sounds	2
	No response	No response	1
Motor response	Moves spontaneously and purposefully	Obeys commands	6
	Withdraws to touch	Localizes painful stimulus	5
	Withdraws in response to pain	Withdraws in response to pain	4
	Responds to pain with decorticate posturing(abnormal flexion)	Responds to pain with flexion	3
	Responds to pain with decerebrate posturing (abnormal extension)	Responds to pain with extension	2
	No response	No response	1
Score $\leq$ 12 suggests a severe head injury			
Score < 8 suggests need for intubation and ventilation.			
Score $\leq$ 6 suggests need for intracranial pressure monitoring			

APPENDIX III ; ESTIMATED BUDGET

ALLOCATION	BREAK DOWN	AMOUNT IN KES.
1. Stationary	4 reams Printing paper@1.000/-	4,000
	Biro pens (1Box) @ 1,000/-	1,000
	10 Folders @200	2,000
2. Ethics board	Ethics Fee	1,000
3.Secretarial services	Typist fees	5,000
	Photocopy	3,000
4.Computer and Printer	Laptop Computer	40,000
	Computer soft wares	6,000
	Printer and Catridges	8,000
	SSPS software	2,000
	Flash disk	1,000
5. Internet hours	50hours@ 60/-	3,000
6. Data collection and analysis	Statistician services	20,000
	Data collection assistant	10,000
7. Selected images	Scanning of images	5,000
	Digital transfer of images	3,000
8.Printing and Binding	Proposal	4,000
	Final report	8,000
9. Contingencies	Contingencies	10,000
	TOTAL AMOUNT	**136,000**