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A retrospective autopsy-based survey of fatal traumatic brain injuries in Benin City, Nigeria

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Abstract

Background: Traumatic brain injury (TBI) is major cause of death in young adults. It results from external force to the head causing injury to the contents of the skull with or without damage to the skull itself.
Aims and objectives: To describe the autopsy findings in patients with Traumatic brain injuries.
Materials and Methods: A Retrospective Study of findings in patients who suffered Traumatic Brain Injuries as seen at autopsy. The historical and autopsy data of all Traumatic brain injury patients whose bodies were received between 2011 and 2021 were analyzed.
Results: TBIs account for 66.7% of traumatic deaths in our institution. Male to female ratio was 1:0.22, and mean age was 39.30±16.65 years. The most common cause of TBI was road traffic accidents (90.9%), with gunshots (5.6%) as a distant second. Intracranial hemorrhages were present in 99.6% of cases and almost all (98.8%) died as a result of Raised Intracranial pressure associated with intracranial hemorrhage. The most common pattern was Subdural hemorrhage (62.65%); followed by Subarachnoid hemorrhage (52.35%); Intraparenchymal hemorrhage (40.88%), Epidural hemorrhage (18.24%); and intraventricular hemorrhage (9.71%). Skull fractures were present in 41.6% of cases.
Conclusion: RTA is the most common cause of traumatic brain injury in our study and the leading cause of traumatic deaths. Multiple injuries appears to contribute less to mortality amongst our TBI patients but this may be due to under reporting of injuries found in polytraumatized patients. Morbidity and mortality due to TBI, and trauma in general, will be reduced by improving road safety, and functional protocols for emergency and prehospital care of trauma patients.

Keywords: Fatal, Traumatic brain injury, Autopsy study, Benin City.

Introduction

Traumatic Brain Injury (TBI) is non-degenerative, non-congenital brain insult, due to external mechanical force that possibly leads to permanent or temporary disabilities of cognitive, physical, and psychosocial functions with or without altered level of consciousness.[1,2] Mechanical force to the head may injure the contents of the skull, with or without a fracture of the skull; and extent and severity of injury is not necessarily proportional to the amount of force applied.[3]

TBIs have huge social and economic impact.[2,3] While, trauma of any kind is a leading cause of death in persons below 45 years and estimated to be responsible for approximately 15,000 deaths annually.[4,5,6] TBI is particularly a major cause of death and disability in the young population.[2] TBI is a public health concern that has been termed a "silent epidemic".[3] It is responsible for 1-2% of all deaths and one third to half of all traumatic deaths.[7] There is a rising incidence of TBI worldwide, and especially in developing countries, associated with increased mechanization, and poor compliance with safety guidelines.[2,3,8] A large proportion of these are due to Road traffic accidents (RTAs).

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Approximately 1.3 million people die due to road traffic accidents (RTAs) each year and 20–50 million sustain non-fatal injuries.[9] The World Health Organization in its Global Status Report on Road Safety, also warned that road fatalities will be the 5th biggest killer by year 2030.[10]

Clinical and radiological assessment do not always reveal the full extent of head injury. Autopsy findings in brain trauma deaths, help fill the gaps in clinical examination and investigation.[2] This study describes the current epidemiology, pattern of injury and as well as the causes/ mechanisms of death associated with TBI in Benin City. This will enhance planning, implementation and evaluation of policies aimed at prevention and reduction of morbidity/mortality associated with brain trauma. It can also guide protocols for care of neurotrauma patients in prehospital and emergency hospital settings.

Materials and method

Study design

This is a retrospective aimed at describing the autopsy findings in patients who suffered fatal Traumatic Brain Injuries.

Study location

The University of Benin Teaching hospital is a major referral center for neurotrauma cases, serving a population of approximately 15 million people across eight states in the southern part of Nigeria. The location of Benin City, at the confluence of several interstate highways to the northern, southern, eastern and western parts of Nigeria makes our center the first point of call in many instances of RTA occurring on these highways.

Study subjects/participants

All patients with traumatic brain injuries who died between January 2011 and December 2021.

Autopsy procedure/techniques

Brain dissection during autopsy involved documentation of scalp injuries and incision of the scalp from ear to ear over the vertex. The anterior and posterior flaps of the scalp were then reflected forwards and backwards. Details of injuries underneath the scalp were recorded. Presence of calvaria fractures were noted where present. The skullcap was removed by sawing around and through the bone up to the inner table, then gently inserting and twisting the chisel at intervals through saw cuts. The dura was removed by a cut following the line of sawed calotte and pulling from front to back. The brain was removed by inserting four fingers between the frontal lobes and the skull and drawing them backwards and severing its attachments to the skull base. Presence of skull base fractures were noted where present, after peeling the basal dura. The weight, symmetry, leptomeninges and surface anatomy of the brain as well as the state of the brain gyri and sulci were noted and inspected for abnormalities and evidence of brain herniation(s). Serial sections of the brain were further examined in the fresh or fixed state, for contusions, brain lacerations, heamorrhages (epidural, subdural, subarachnoid, parenchymal, and intra-ventricular bleeds), Edema. The other aspects of postmortem exam followed usual autopsy protocols and non-cranial injuries were noted and documented when present.

Radiological and laboratory techniques/ procedures

Histology, microbial studies, blood and body fluid analysis were done as needed, to establish diagnoses, cause and manner of death

Data collection procedure

Clinical history and demographic characteristics such as age, gender, cause of head injury, were obtained from the patients' case records, inquest papers or relatives of the deceased; while autopsy findings were obtained from the daybook/registers/ledgers in the Pathology Department.

Data analysis

All data obtained was analyzed using Statistical Programme for Social Sciences, version 20 (SPSS 20, IBM Corp, Armonk, NY, United states of America). Observations were compared with findings in the literature.

Ethical considerations

Confidentiality of the identity of the patients and personal health information is maintained.

Table 1: Causes of traumatic brain injury

Causes of Traumatic Brain Injury	Frequency	Percent
RTA	618	90.9
Gunshot	38	5.6
Assaults (Blunt trauma, machete cuts, other penetrating injuries)	17	2.5
Falls	3	0.4
Unknown	4	0.6
Total	680	100.0

RTA = Road traffic accident

Table 2: Pattern of intracranial bleeds

Pattern of bleeds	**Percent**
Epidural hemorrhage	18.24
Subdural hemorrhage	62.65
Subarachnoid hemorrhage	52.35
Intraparenchymal hemorrhage	40.88
Intraventricular hemorrhage	9.71

** Intracranial hemorrhages were present in various pattern combinations in 99.6% of all cases, with massive, multi-compartment bleeds, occurring in 47.2% of cases.

Table 3: Types of head injury in relation to causes

Causes of Injury	Intracranial hemorrhage	Skull fracture	Brain Contusion / Laceration
RTAs	616	229	272
Gunshot Wound	38	38	38
Assaults	17	12	9
Falls	3	3	1
Unknown	4	1	1
	677(99.6%)	283(41.6%)	321(47.2%)

RTA = Road traffic accident

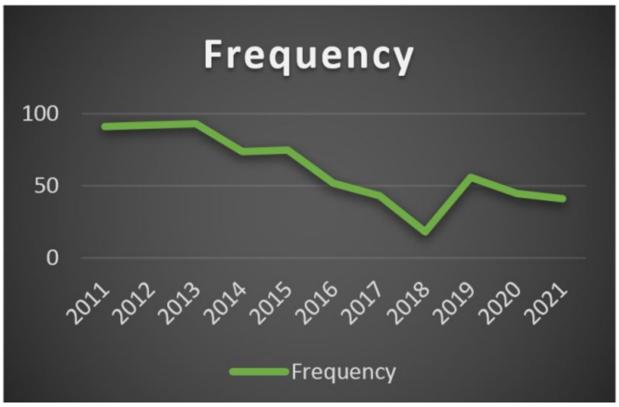

Figure 1: Yearly frequency over the period of study

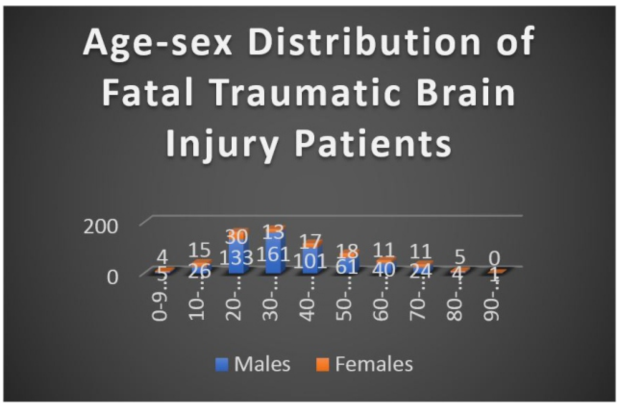

Figure 2: Age-sex distribution of fatal traumatic brain injury patients

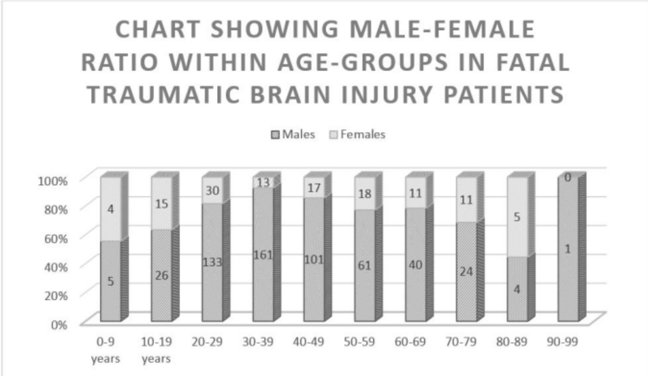

Figure 3: Male-female ratio within age-groups

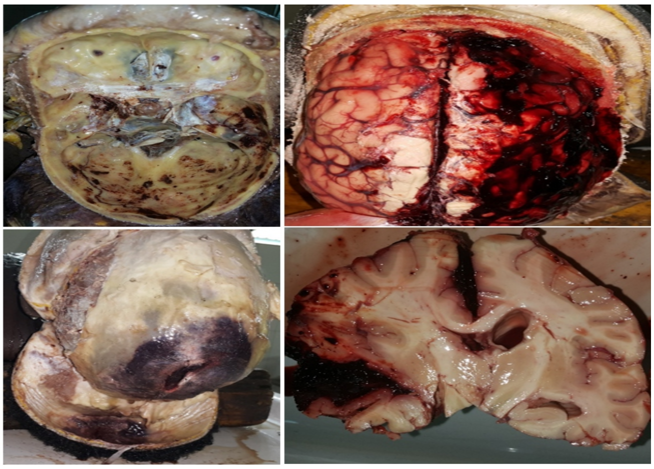

Figure 4: photographs showing various head injury
Top Left: Basal skull fracture involving the right petrous bone.
Top Right: Subdural and subarachnoid hemorrhage
Bottom Left: Hard contact Gunshot entry wound on the skull , showing round defects in the scalp, pericranium and, skull; with surrounding hematoma and tissue reaction.
Bottom Right: Cerebral hemorrhage with extension into the temporal horn of the left lateral ventricle. In comparison the right temporal horn is clear.

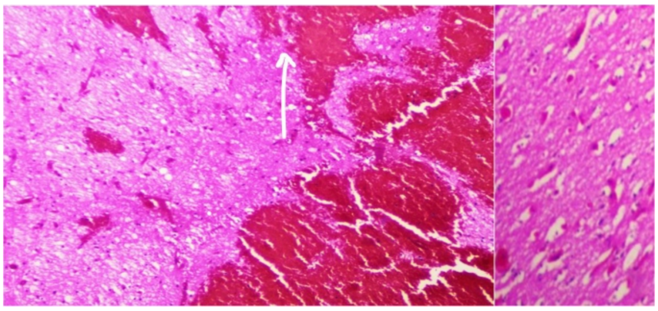

Figure 5: Photomicrographs of brain tissue showing hemorrhage, and edema on the left. Red neuron change due to hypoxia is seen on the right.

Results

Autopsies were performed on 3,620 cases, 1020 cases (28.2%) were traumatic deaths. Traumatic brain injuries present in a total of 680 cases, constituted 18.8% of autopsies done and 66.7% of all trauma deaths. Yearly frequency over the period of study is displayed in **figure 1** showing highest rates in the first three years with a decreasing trend in the number of yearly cases seen starting from the year 2014. The lowest numbers is observed in 2018 followed by a smaller peak.

There were 556 males (81.8%) and 124 females (18.2%); giving a male to female ratio of 1:0.22. Age range was 1-96 years, with a mean age of 39.30±16.65 years. Majority of cases (58%) aged between 20 and 49 years of age, with a peak in the 30-39year age-group (25.6%). Children below 18 years of age constituted only 5.29% of cases, while the elderly (persons above 65 years) constituted 8.7%. Male-female ratio in relation to age-groups of fatal traumatic brain injury patients shows higher percentages of females at the extremes of age and lesser percentages in the years between compared to males. Age-Sex distribution **(figure 2)**; and male-female ratio in relation to age-groups **(Figure 3)**, are as displayed.

The causes of traumatic brain injuries were, RTA in 90.9% of cases. These involved motor vehicle occupants, motorcycle, bicycle and tri-cycle riders, as well as pedestrians. Other causes include, gunshots to the head (5.6%); other assault related injuries involving blunt force to the head or penetrating injuries e.g. due to machete cuts (2.5%); and falls (0.4%). In a few cases (0.6%) cause of head injury were unknown. Frequencies and percentages are as displayed in **table 1**.

Intracranial hemorrhages were present in various pattern combinations, in 99.6% of fatal TBIs examined. **(Table 2)**. Subdural hemorrhage was present in 62.65%; followed by subarachnoid hemorrhage in 52.35%; Intra-parenchymal hemorrhage in 40.88%, associated with intra-ventricular hemorrhage in 9.71% and epidural hemorrhage in 18.24%. Massive, multi-compartment bleeds, were present in 47.2% of cases accompanied by sub-galeal hematoma, fractures, brain contusions and/or laceration. Location/type of bleed was not specified in 4.4% of cases. Skull fractures were present in 41.6% (283) of cases, a third (14.12%) of which had basal skull fractures in isolation or in combination with skullcap fractures. The major types of injury observed in relation to causes of injury is displayed in **Table 3**. Other gross findings include scalp lacerations, brain contusions and lacerations, and herniations. **Figure 4** shows photographs of selected gross findings. Findings on histopathological evaluation when done included, oedema, inflammation, as well as neuronal and glial changes due to secondary hypoxic-ischemic injury **(figure 5)**.

Associated/multiple injuries were documented in only a few (2.65%) of our TBI patients. Most were musculoskeletal injuries, while spinal cord and abdominal injuries contributed a minute fraction. In 98.8% of cases, death was due to intracranial hemorrhage with Raised intracranial pressure. Multiple injuries resulting in exsanguination/hemorrhagic shock contributed a minute fraction.

Discussion

The aim of this study is to describe the autopsy findings in patients who suffered fatal TBIs. TBIs account for 66.7% of traumatic deaths in our institution. The most common cause of TBI was road traffic accidents (90.9%), with gunshots (5.6%) as a distant second. Intracranial hemorrhages were present in 99.6% of cases and Skull fractures in 41.6% of cases. Almost all died as a result of Raised Intracranial pressure associated with intracranial hemorrhage. The most common pattern of bleed was subdural hemorrhage while intra-ventricular hemorrhage was least common.

Yearly frequency over the period of study shows a sustained decreasing trend starting from the year 2014, except for a slight rise in 2019. This observed fall corresponds to and may be explained by the statewide ban on the use of commercial motorcycles which commenced in the year 2013. The low number observed in 2018 was however mostly due to industrial strike action by health workers in our institution, which lasted for some months of that year.

The male to female ratio of 1:0.22 is similar to what has been published in other studies.[3,8] Male predominance in head injury has been reported by many workers.[11-14] The reason being the higher participation of males in activities that tend to put them at risk.[3] Male-female ratio in relation to age-groups of fatal traumatic brain injury patients shows higher proportions of females at the extremes of age where gender roles appear less well defined. This presumably, is because during the childbearing age, more women tend to children and the home while males fend for the family or at least travel more and are exposed to more travel risks/adventures. Roles are relatively less defined in childhood, as male and female children have similar independence and exposure to risks though males may indulge more in risky behavior. Also in the older age groups, more females again begin to fend for themselves probably reflecting increasing voluntary or involuntary new found independence, associated with children growing and leaving home; increasing responsibilities with career advancement; or due to separation, divorce or widowhood.

Fatal TBI affects the young.[3] In our study, persons between 20 and 50 years of age were predominantly affected, with a peak in the 30-39year age-group. Like in our study, RTA are often found to be the most common cause of TBI in other places.[3,8] Both the male predominance and the youth of persons dying in RTAs on a global level are well documented.[9] RTAs are the most common cause of TBI in our study followed by gunshots to the head, other assaults involving blunt force, or penetrating injuries to the head, and falls. Studies found that men in Great Britain drive twice as many kilometers per year as women; are more likely to drive at higher speeds or under the influence of alcohol and drugs and thus more likely to die in a road traffic collision.[15,16]

RTAs involve passengers in motor vehicles, motorcycles, and tri-cycles, as well as pedestrians. We believe that the statewide ban imposed on the use of commercial motorcycles and tricycles on major highways in Edo state starting from the year 2013, contributed significantly to the drop in the number of fatal TBIs seen in that year and afterwards, compared to the years preceding the ban. In an autopsy based study of fatal road traffic collisions in Italy,[8] the rate of head injuries was found to be extremely higher amongst cyclists and pedestrians, than in other road users who appeared relatively better protected by airbags, seatbelts, or helmets. Motorcyclists sustained the lowest incidence of TBIs among all road users, seemingly due to the protective helmets. They sustained fewer fractures of the skullcap; though the helmets seemed less protective against base of the skull fractures. On the other hand, cyclists who did not use helmets died more at the scene of the accident.[17] Studies also suggest that many cyclist who did not wear helmets could have been saved just by wearing one.[18]

There's a low incidence TBIs at the extremes of age as vulnerable groups tend to be protected from risky activities. However both accidental and non-accidental injury may be seen within these groups.[3,19] Overall, children under 18 years of age accounted for 5.29% of fatal TBI cases seen, while the elderly (persons above 65 years) constituted 8.7%. Authors have found that, mortality amongst children is lower than in the general populace despite high frequency of severe TBI amongst children; suggesting greater recovery/resilience amongst children with TBI compared to adults.[20,21] It has also been documented that TBI is commoner among boys due to the greater tendency of the male child to undertake risky adventures.[22,23] The effect of this is easily lost (as seen in figure 3); in localities like ours where TBIs are mainly due to RTAs which are not greatly influenced by childhood behavioral patterns.[20,21,24] RTA related TBIs in children is associated with lack of safe school buses, or inadequate measures protecting children commuting to school on foot and/or, lack of supervision for children hawking wares on the streets, or playing around street side shops.[4,5,20]

Skull fractures occurred in 41.6% of cases majority involving the vault alone, while a third of cases had basal skull fractures. Skull fracture rates as high as 71-90% of cases of TBIs have been reported, involving vault and/or the base of skull.[3,25-27]

Intracranial hemorrhages were present in various pattern combinations in 99.6% of our cases, with massive, multi-compartment bleeds, occurring in 47.2% of cases. Subdural hemorrhage was the commonest present in 62.65%; followed by subarachnoid hemorrhage in 52.35%; Intra-parenchymal hemorrhage in 40.88%, associated with intra-ventricular hemorrhage in 9.71% and epidural hemorrhage in 18.24%. Many authors similarly report subdural and subarachnoid bleeding as the most common type of intracranial haemorrhage followed by intra-parenchymal haemorrhage, with epidural and intra-ventricular bleeds occurring least often. Though with wide differences in the rates reported.[2,3,12,25,27-29] The variation in rates reported may reflect differences in the prevalent mechanisms of injury and/or differences in methods of assessing and reporting intracranial hemorrhages.

Secondary brain injuries resulting from swelling and compression of brain tissue, hypotension, has been linked with delay in neurosurgical intervention often associated with clinical deterioration.30 Autopsy studies have also shown that significant intracranial bleeds and brain contusion, as well as significant chest and abdominal trauma, may go undetected during antemortem evaluation,[27-29] such that wide variations in length of survival, and ultimate outcomes after injury, are reflective not only of the severity of initial injury but also of differences in timely identification of injuries, triaging and monitoring of patients, as well as interventions.

Multiple injuries were noted in an unexpectedly small fraction (2.65%) of our TBI patients probably due to poor documentation. Most were limb skeletal and soft tissue injuries, while spinal cord and abdominal injuries made up the rest. Other authors have documented associated cervical spine injuries in up to 3.3% of TBIs;[2] and as high as 40%-48% in motorcyclists and motorbike fatalities.[8] Rates of abdominal and chest trauma found at autopsy in fatal head injury have also been documented to be as high as 15% and 30% respectively. However higher rates are of multiple injuries are seen in blasts injuries than in RTAs.[2]

In 98.8% of our cases, cause of death was intracranial hemorrhage with raised intracranial pressure. Multiple injuries resulting in exsanguination/hemorrhagic shock contributed a minute fraction. Cause of death in RTAs are mainly traumatic head injuries, multiple injuries, or a combination of the two, since multiple injuries are present in many cases of severe head injuries and vice-versa.[2,8] Other studies have equally documented hemorrhage shock due to thoracic or abdominal injuries as the second most frequent mechanism of death in polytrauma cases as seen in our study.[2]

Limitations of this study include paucity of documentation of exact anatomical sites of head/brain injuries and other musculoskeletal and visceral injuries, especially in cases where limited autopsies were performed. Also, histopathological evaluation and other ancillary investigations like toxicology were performed only as needed in few cases to establish cause, mechanism or manner of death. We recommend prospective studies to describe more accurately the spectrum of autopsy findings associated with traumatic brain injuries in our environment.

Conclusion

RTAs are responsible for most TBI in our environment and males are more affected. Such rates suggest poor attitudes towards traffic laws, and poor maintenance of vehicles and roads. Increased road safety campaign, legislations, and enforcement of relevant policies, with development of high-quality trauma system, and provision of pre-hospital/emergency medical services are advocated to reduce mortality due to TBIs in our environment

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