Clinical Profile and Autopsy Findings in Fatal Head Injuries

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Abstract

Aims: This study aims to correlate the autopsy findings with the clinical picture and imaging report in fatal head injury patients.

Settings and Design: A descriptive study conducted at tertiary care hospital in South India from July 2015 to December 2016.

Patients and Methods: All patients with head injuries who were admitted to our Emergency and Trauma Centre and underwent autopsy were included in the study. A structured pro forma was used for collecting information. Autopsy findings were considered as a gold standard to correlate with antemortem findings in fatal head injury. The data were analyzed with EpiData and OpenEpi statistical analyzing software.

Results: Of the 303 fatal head injury patients, a majority were males and age group between 21 and 40 years. Eighty-eight percent (267/303) of fatal head injuries were due to road traffic accidents. Twenty-five of the 303 patients reached our center within 1 h (golden hour) of trauma. Of the 303 fatal head injuries, 153 (50.5%) died within 24 h of reaching our center. The most common autopsy finding in this study was subarachnoid hemorrhage (SAH) (247/303, 81.3%). Diagnostic accuracy of epidural hemorrhage (EDH) antemortem had the highest value (98.35%). SAH had least diagnostic accuracy value (45.72%). Subdural hemorrhage (SDH) had highest sensitivity (57.02%). EDH had higher specificity (100%). Significant SDH, SAH, and brain contusions were not detected during antemortem evaluation.

Conclusions: Our study revealed that among fatal head injury patients, half of them died within first 24 h after reaching to tertiary care center. Diagnostic accuracy to detect extradural hemorrhage antemortem had the highest value and SAH had least diagnostic accuracy value. Significant subdural hemorrhage, subarachnoid hemorrhage, and brain contusion were not detected during antemortem evaluation. Expertise in interpretation of imaging, adequate clinical examination, proper documentation, and early resuscitation may reduce the chances of missed injuries in head injury patients.

Keywords: Antemortem, autopsy, head injury, postmortem, traumatic brain injury

INTRODUCTION

Head injury is a major public health and socioeconomic problem causing death and disability particularly among young population throughout the world. Nowadays, the term “head injury” has been replaced by the new term “traumatic brain injury (TBI).” TBI is defined as “cerebral insult not degenerative or congenital nature, 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] The incidence of TBI is rising worldwide because of increased mechanization, inadequate traffic education, and poor implementation of traffic safety rules, especially in developing countries like India.

In India, most of the deaths due to road traffic accidents (RTAs) take place within 24 h of injury, mostly before reaching the hospital. This is mainly due to delay in access to a health-care facility.[2] Lack of first aid, delay in transfer of patients, longer transport time, absence of triage, and lack of facilities in hospitals are some major problems of trauma care in India.[3][4]

Studies on mortality including postmortem examination are few and far between. Autopsy is the final procedure of choice for finding out the exact cause of death. In head injuries, diagnosis by clinical and radiological assessment may not reveal the full extent of injuries. In patients who succumb to their illness, autopsy may detect the lacunae in clinical diagnosis and investigation. These autopsy findings are a valuable source of information. This is a unique opportunity to

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identify the exact cause of death. It may be possible to modify the protocol for care of neurotrauma patients in the prehospital and emergency hospital setting following this study. That is the main purpose of this study.

**Patients and Methods**

This descriptive study was conducted in a tertiary care hospital in South India from July 2015 to December 2016. All patients with head injuries who were admitted to our Emergency and Trauma Centre and underwent autopsy were included in the study. The aim of this study was to describe the autopsy findings and correlate the autopsy findings with the clinical picture and imaging report in fatal head injury patients. A structured pro forma was used for collecting information. Clinical history and demographic characters such as age, gender, cause of head injury, first aid details, time lag, severity of head injury, and pattern of head injury were collected from the patients’ case records.

Computed tomography (CT) findings such as extradural hematoma (EDH), subdural hematoma (SDH), subarachnoid hemorrhage (SAH), skull fractures, cerebral contusions, and intraventricular hemorrhage (IVH) which were recorded by qualified neurosurgeons in the case records were documented. Noncranial antemortem injuries such as chest trauma, abdominal trauma, spine injury, upper limb fracture, lower limb fracture, and pelvic injury were documented from case records. Once the patient with head injury expired, autopsy was carried out by the Forensic Medicine and Toxicology specialist. The description of head injuries at autopsy was classified as scalp injuries, skull fractures, EDH, SDH, SAH, brain contusion, brain laceration, and IVH. Other system findings at autopsy were classified as chest trauma, abdominal trauma, spine injury, upper limb fracture, lower limb fracture, and pelvic injury. All these autopsy findings were documented in the pro forma.

Data were entered with the help of EpiData version 3.1 and analyzed using EpiData analysis software (version 2.2.1.178) and OpenEpi software (EpiData Association, Denmark). Patients’ sociodemographic characteristics and autopsy findings in fatal head injuries were expressed in proportions. Correlation of autopsy findings with antemortem findings was expressed as sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy using OpenEpi software. Autopsy findings were considered as a gold standard to correlate with antemortem findings in fatal head injury. In cases when head injury patients underwent surgical treatment (like evacuation of hematoma), then intraoperative findings also were considered as gold standard. This study was approved by Institute Ethics Committee of our institute.

**Results**

During the 1½-year study period, 346,933 patients attended the emergency and trauma department at our institution. Out of this, 12,621 patients came with multiple traumatic injuries. Three thousand three hundred and two patients referred for neurosurgery consultation. Two thousand seven hundred and thirty-nine neurotrauma patients were admitted during the study period. Out of this, 303 expired, leading to mortality of 11.1%. At present, all fatal head injuries cases undergo autopsy in our institution for medicolegal purposes. Of the 303 fatal head injury patients, the most commonly affected age group was between 21 and 40 years (119, i.e., 39.3%). Majority were males (266, i.e., 87.8%) when compared to females (37, i.e., 12.2%). Eight-eight percent (267/303) of fatal head injuries were due to RTAs. Fall from height was the cause of head injury in 8% (23/303) followed by assault in 3% (10/303). Twenty-five of 303 (8.3%) patients reached our center within 1 h (golden hour) of trauma. A majority of patients numbering 159 (52.5%) reached our center within 2–6 h after injury. Of the 303 fatal head injuries, 153 (50.5%) died within 24 h of reaching our center [Figure 1]. Ninety-five died within first 12 h. Ninety-two of the remaining (30.4%) died 2–7 days after reaching to our hospital [Figure 2]. A majority of fatal head injuries (234, i.e., 77.2%) presented with Glasgow Coma Scale (GCS) of <8 (severe head injury) on arrival. Thirty-two patients (12.6%) presented with moderate head injury (GCS 9–12). Thirty-one patients (10.2%) with mild head injury died subsequently during treatment. Of 303 fatal head injury patients, 58 underwent emergency neurosurgical management (19.1%). The remaining 245 patients (80.9%) were managed nonoperatively.

The most common autopsy finding in this study was SAH (247/303 that is 81.3%). Other common autopsy findings were subdural hemorrhage (SDH) (228/303 that is 75%), skull fractures (205/303 that is 67.4%), cerebral contusion (124/303 that is 40.8%), and IVH (36/303 that is 11.8%). Least common autopsy finding was Epidural hemorrhage (EDH) which constituted 26 out of 303 cases (8.6%) [Figure 3]. In many patients, these findings overlapped with each other leading to a more adverse outcome. Of the 303 fatal head injuries, 152 (50.2%) had isolated head injury without involvement of other systems. One hundred and fifty-one (49.8%) had other systemic injuries such as chest trauma (93/303 i.e., 30.6%), abdominal trauma (46/303 i.e., 15.1%), upper limb fractures (43/303 i.e., 14.2%), lower limb fractures (41/303 i.e., 13.5%), pelvic injury (10/303 i.e., 3.3%), cervical spine injury (10/303 i.e., 3.3%), and dorsolumbar spine injuries (5/303 i.e., 1.7%) along with head injury.

![Figure 1: Distribution of time interval between incidence and arrival to our hospital in fatal head injuries during study period (n = 303)](image-url)
The distribution of head injury lesions and other system injuries at autopsy and antemortem were expressed in Table 1. It showed number of lesions missed during antemortem evaluation with proportion of significant missed lesions.

Table 2 showed the correlation of autopsy findings with antemortem findings in fatal head injuries and other system injuries, expressed as sensitivity, specificity, positive productive value, negative predictive value, and diagnostic accuracy.

**Discussion**

Trauma is one of the leading causes of mortality worldwide. Head injuries form a significant proportion, especially in developing countries. 

RTAs are the most common cause of fatal head injury. 

Even though the mortality due to head injury is high, data regarding the exact cause of death and clinically significant missed injuries in emergency department are rare in India. 

An analysis of head injuries in fatal cases can give insight into the standards of emergency management. We feel that the large amount of data available through medicolegal autopsies has not been used effectively for research purposes. In this study, the medicolegal autopsy data has been used to evaluate the emergency medical practice with reference to head trauma.

In fatal head injuries, the median age was 43 years (ranging from 2 months to 86 years) in this study. Nearly two-thirds of fatal head injuries were in age group between 21 and 60 years and majority were males. This compares favorably with reports of similar studies in India and Western studies. 

The most common cause of fatal head injury followed by fall from height and assault (10/303, 3%). Of the 267 fatal head injuries due to RTAs, 54% (144/267) were involved in two-wheeler accidents either by loss of control or collision with another two-wheeler or four-wheeler. One-fourth of the victims were pedestrians hit by either a motorized two-wheeler or four-wheeler. A Western study showed that four-wheeler occupants were affected more by TBI in high-income countries, whereas pedestrians, cyclists, and motorcyclists were often affected by TBI in middle- and low-income countries. This is because four-wheeler usage is more common in the West. On the other hand, motorized two-wheelers are the main mode of transport in the Third World.

In our study, only 8.3% reached our center within the golden hour after trauma. A majority of patients (159, 52.5%) reached emergency trauma care center within 2-6 h after injury. This was probably because of lack of immediate transportation and lack of fully equipped trauma care center within reasonable distance. About 50.5% of patients died within first 24 h after reaching to our center, in which 31.4% (95/303) of patients died within first 12 h. Primary brain injury, secondary brain injury, and hemorrhagic shock were the causes of death in those patients. Wearing helmet, avoidance of alcohol while driving, strict implementation of traffic rules, and health education may probably reduce these early deaths. In a Western study, 45% of the individuals died within 60 min of trauma. The second peak occurred within 1-4 h of trauma in about 34% of patients. The third peak occurred after 1 week of trauma in 20% of victims. Brain injury was the leading cause of death in their polytrauma cases. Early deaths up to 24 h and in 1st week were often due to TBI. The second frequent cause of death was hemorrhage mainly due to thoracic or abdominal injuries. Our figures match with various Indian and Western studies with reference to early mortality.

**Autopsy findings in fatal head injury**

The most common autopsy finding in this study was SAH (247/303 that is 81.3%). Least common autopsy finding was Epidural hemorrhage (26/303, 8.6%). Of the 303 fatal head injury patients, 20 had a combination of both SDH and SAH. Three had skull fracture with EDH. Eight had isolated SAH without any other intracranial lesions. Three had isolated skull fracture without any other intracranial lesion. Twenty-eight patients died due to other system injuries. In these patients, the associated injury had not been detected during the antemortem management. It is possible that more thorough workup might have saved these patients. However, it is also possible that these were missed because the patients were in shock and sensorium was abnormal. It is also possible that some other patients died before they could be examined, and clinically, they were presumed to have head injury because of altered level of consciousness. An autopsy study from Gujarat reported that skull fractures (91.67%), intracranial hemorrhages (92.5%), and brain injuries (92.5%) were the most common findings in head injuries. The most common
type of intracranial hemorrhage in their study was subdural hemorrhage (SDH) involving 83% followed by subarachnoid hemorrhage (SAH) in 28% cases and IVH in 17%. This figure differs from our study and the reason was not clear.

**Extradural hemorrhage**

Of the 303 fatal head injuries, 26 (8.6%) had EDH on postmortem evaluation. Twenty-one were diagnosed during antemortem evaluation. Five were not detected, out of which one patient died before CT was done. These five patients could have been saved if diagnosed earlier during antemortem evaluation. Considering the autopsy findings as gold standard, the sensitivity, specificity, and diagnostic accuracy to diagnose EDH antemortem was 80.77%, 100%, and 98.35%, respectively. In our study, the least common type of head injury was EDH which was similar to other Indian studies.[11,14]

**Subdural hemorrhage**

Of the 303 patients, 228 (75%) had SDH at autopsy. Ninety-eight lesions were missed, out of which 72 patients had significant SDH which could have contributed to an adverse outcome. As per our criteria, SDH volume of 25 ml or more and involvement in two or more regions of the brain (frontal, parietal, temporal, occipital, and cerebellum) in autopsy was considered as significant SDH. Fourteen patients died before CT was done. The sensitivity of diagnosing SDH in antemortem was 57.02%. Specificity was 78.95%. Diagnostic accuracy for SDH was 62.5%. However, it is very well known that SDH is often accompanied by underlying brain damage. Hence, the outcome is likely to be more unsatisfactory.

**Subarachnoid hemorrhage**

Of the 303 patients, 247 (81.3%) had SAH. Ninety-four cases were diagnosed during antemortem. One hundred and fifty-three were not detected, of which 45 patients had significant SAH lesions. Those who had SAH involving the whole base of brain or one cerebral hemisphere or both cerebral hemispheres were considered as significant SAH in our study. The remaining 108 missed SAH cases had only thin film of SAH that might not have been responsible for death due to SAH. In 84 cases (27.6%), SDH and SAH were

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### Table 1: Distribution of head injury lesion and other system injuries at autopsy and antemortem (n=303)

| Lesion                        | Autopsy | Antemortem diagnosis (true positive) | Missed in antemortem diagnosis | Significant lesions missed in antemortem diagnosis |
|-------------------------------|---------|--------------------------------------|-------------------------------|--------------------------------------------------|
| Head injury lesions           |         |                                      |                               |                                                  |
| Extradural hemorrhage         | 26/303  | 21                                   | 5                             | -                                                |
| Subdural hemorrhage           | 228/303 | 130                                  | 98                            | 72/98                                            |
| Subarachnoid hemorrhage       | 247/303 | 94                                   | 153                           | 45/153                                           |
| Brain contusion               | 124/303 | 63                                   | 61                            | 41/61                                            |
| Skull fractures               | 205/303 | 99                                   | 106                           | -                                                |
| Intraventricular hemorrhage   | 36/303  | 13                                   | 23                            | -                                                |
| Other system injuries         |         |                                      |                               |                                                  |
| Cervical spine injury         | 10/303  | 3                                    | 7                             | -                                                |
| Chest trauma                  | 93/303  | 31                                   | 62                            | 33/62                                            |
| Abdominal trauma              | 46/303  | 19                                   | 27                            | 20/27                                            |

### Table 2: Overall diagnostic accuracy of head injuries and other system injuries during antemortem evaluation (n=303)

| Lesion                          | Sensitivity (%) | Specificity (%) | Positive predictive value (%) | Negative predictive value (%) | Diagnostic accuracy (%) |
|---------------------------------|-----------------|-----------------|------------------------------|-------------------------------|-------------------------|
| Head injuries                   |                 |                 |                              |                               |                         |
| Epidural hemorrhage             | 80.77           | 100             | 100                          | 98.23                         | 98.35                   |
| Subdural hemorrhage             | 57.02           | 78.95           | 89.04                        | 37.97                         | 62.5                    |
| Subarachnoid hemorrhage         | 38.06           | 78.95           | 88.68                        | 22.73                         | 45.72                   |
| Brain contusion                 | 50.81           | 71.11           | 54.78                        | 67.72                         | 62.83                   |
| Skull fractures                 | 48.29           | 94.95           | 95.19                        | 47                            | 63.49                   |
| Intraventricular hemorrhage     | 36.11           | 95.52           | 52                           | 91.76                         | 88.49                   |
| Head injury with other system injuries |          |                 |                              |                               |                         |
| Chest trauma                    | 33.33           | 97.16           | 83.78                        | 76.78                         | 77.63                   |
| Abdominal trauma                | 41.3            | 98.06           | 79.17                        | 90.36                         | 89.47                   |
| Upper limb fractures            | 86.05           | 97.31           | 84.09                        | 97.68                         | 95.71                   |
| Lower limb fractures            | 97.56           | 97.71           | 86.96                        | 99.61                         | 97.69                   |
| Pelvic fractures                | 60              | 99.32           | 75                           | 98.64                         | 98.02                   |
| Cervical spine injury           | 30              | 98.29           | 37.5                         | 97.63                         | 96.04                   |
| Other spine injury              | 20              | 99.66           | 50                           | 98.67                         | 98.35                   |
present in the cerebellar region. Six patients died before CT was done. The sensitivity of diagnosing SAH in antemortem was 38.06%. Specificity was 78.95%. Diagnostic accuracy of the same was 45.72%. An autopsy study from Iraq\cite{12} showed that subarachnoid hemorrhage was the most common intracranial lesion (42.68%) followed by subdural hemorrhage (34.45%). Skull fractures were seen in 32.77% of cases. This figure matches with our study.

**Brain contusion**

Of the 303 patients, 124 (40.8%) had brain contusion on autopsy. Sixty-three (true positive) were diagnosed during antemortem. Fifty-two were wrongly diagnosed (false positive) as brain contusion in antemortem, but it was not confirmed at autopsy. Sixty-one lesions were missed, of which 41 were considered significant brain contusion. In our study, the brain contusion which had length of five cm or more or associated with brain laceration was considered as significant brain contusion. The remaining 20 missed lesions had small brain contusion. Four patients died before CT could be done. The sensitivity of diagnosing brain contusion in antemortem was 50.81%. Specificity was 71.11%. Diagnostic accuracy was 62.83%. In our study, the reason for low sensitivity, specificity, and diagnostic accuracy was probably due to confusion among the treating physician and radiologist to differentiate between SAH and brain contusion. There is very little role for surgical management in brain contusion; the significance of this finding has to be assessed further.

**Skull fractures**

Site: Of the 303 head injuries, 205 (67.4%) had skull fractures. A majority of skull fractures (106) involved the cranial vault followed by involvement of base of skull (65). In 34, fractures involved both cranial vault and skull base. Forty-five percent of skull base fractures involved in middle cranial fossa, 28% involved in anterior cranial fossa, and 27% involved in posterior cranial fossa. In 142, there was a single fracture. Fifty-six had two fractures. Six had three fractures. Two cases had four and more fractures. Most common type of skull fracture was fissure (linear) fracture (140), followed comminuted fracture (55), Hinge fracture (6), diastatic fracture (5), and ring fracture (3). In all these fractures, 6 were depressed skull fractures.

Of the 303 patients, 205 (67.4%) had skull fractures on autopsy. Ninety-nine were diagnosed antemortem and 106 were not detected. Basal skull fractures were missed more than cranial vault fractures. Considering the autopsy findings as gold standard, the sensitivity of diagnosing skull fractures in antemortem was 48.29%. Specificity was 94.95%. Diagnostic accuracy with reference to skull fractures was 63.49%. An autopsy study from Maharashtra\cite{14} reported that skull fracture had occurred in 87.30% of patients. The fissured fracture was the most common type of fracture (59.2%). Majority were a combination of both cranial vault and base of skull fractures rather than individual fractures. In our study, the most common skull fracture was linear (fissure) fracture which matches with the above studies.\cite{11,14} In our study, individual fractures (either cranial vault or base of skull) were more common than combination of both. This finding differs from the above study.\cite{14} This was probably because the mechanism of head injury differs between these regions. This study showed that a lot of basal skull fractures were missed and not documented during antemortem evaluation. It is a well-known fact that isolated skull fractures without any intracranial lesion itself will not cause any harm to patients. However, documentation of these fractures will be helpful from a medicolegal point of view.

**Intraventricular hemorrhage**

Of the 303 patients, 36 (11.8%) had IVH at autopsy. Thirty-one were diagnosed and 23 were missed in antemortem evaluation. The sensitivity of diagnosing IVH in antemortem was 36.11%. Specificity was 98.29%. Diagnostic accuracy with reference to IVH was 96.04%. Cervical spine injury in five patients were diagnosed wrongly (false positive) antemortem which was not found at autopsy of same patients. This can be explained that some cervical spine fractures such as spinous process fractures are very well visualized in X-rays rather than autopsy. It is very well known that all head injury patients presumed to have associated cervical spine injury unless proven otherwise. Application of hard cervical collar is always recommended while evaluating head injury patients in the emergency department.

**Associated chest trauma**

Of the 303 fatal head injury, 93 (30.6%) had chest trauma at autopsy in the form of rib fractures, hemothorax, pleural effusion, and lung contusion. Thirty-one were diagnosed and 62 cases were missed, of which 33 patients had significant chest trauma. Rib fractures associated with underlying hemothorax, lung contusion, and lung laceration were considered as significant chest injury as per our protocol. The remaining 29 missed chest trauma cases had only minimal pleural effusion or pneumonia features, isolated rib fractures. The sensitivity of diagnosing chest trauma in antemortem was 33.33%. Specificity was 97.16%. Diagnostic accuracy was 77.63%.

**Associated abdominal trauma**

Of the 303 patients, 46 (15.1%) had abdominal trauma at autopsy in the form of liver injury, splenic injury, kidney injury, and bladder injury. Liver was the most common injured organ. Nineteen patients were diagnosed and 27 patients were missed in antemortem, out of which 20 patients had significant lesions. In abdominal trauma if liver, splenic, kidney, bladder injuries were found, it was considered as significant abdominal trauma in our study. Remaining seven missed abdominal trauma
cases had only minimal free fluid abdomen that could not have caused death. The sensitivity of diagnosing abdominal trauma in antemortem was 41.30%. Specificity was 98.06%. Diagnostic accuracy with reference to abdominal trauma was 89.47%.

In a series of 119 patients from West,[12] 36 patients (30%) had internal organ injuries in addition to head injury. Spleen and lung were injured in 20 cases (16.81%) followed by liver in 15 cases. A study from Rawalpindi[15] reported that of 43 patients, 12 (28%) had rib fractures, 5 (12%) had lung lacerations, and 5 (12%) had spinal injuries. The proportion of internal organ injury in abdominal trauma in our study compares favorably with the above studies[10,12-15] but differs in pattern of internal organ injuries. Liver was the most common injured organ in our study, whereas spleen and lung were the most common injured organs in the above studies.[12,15] These injuries were due to blasts which are more common in those regions whereas RTAs are more common in our places.

**Conclusions**

Our study revealed that among fatal head injury patients, half of them died within first 24 h after reaching to tertiary care center, out of this one-third died within first 12 h. Half of the patients had isolated head injuries without involving other system injuries. Diagnostic accuracy to detect extra dural hemorrhage (EDH) antemortem had the highest value, and SAH had least diagnostic accuracy value. Significant subdural hemorrhage, subarachniod hemorrhage, and brain contusion were not detected during antemortem evaluation. Along with head injury, significant chest and abdominal trauma were also not detected in antemortem evaluation. Expertise in interpretation of imaging, adequate clinical examination, proper documentation, and early resuscitation may reduce the chances of missed injuries in head injury patients. This data will be required to plan for early detection and treatment of head injury patients.

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**Conflicts of interest**

There are no conflicts of interest.

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