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A prospective cross-sectional study on the cases in a tertiary care hospital about the patterns of head injury caused by falling from heights

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ABSTRACT

Background: One of the most common injuries and death in India are caused by falling from heights. Although a majority of these bereavements are accidental and are due to a slip from higher altitudes like multi storey buildings, trees, construction sites, etc., alcohol consumption also plays a vital role. In such occurrences of death due to falling from heights, head injury is a very common phenomenon and it complicates the investigation procedure for the investigators and the medico legal experts to arrive at a conclusion because these injuries impersonate the injuries sustained from other accident cases like a road accident per say. Due to the absence of eyewitness in most of these cases, a detailed analysis on the pattern and the nature of the injuries is required to arrive at a conclusion. These injuries sustained vary owing to the site of impact and the stature from where the victim had fallen and the critical answer to the medico legal queries lies in a detailed autopsy of the victim's body and a thorough examination at the scene of occurrence. On the account of a comprehensive study insufficiency in Tamilnadu, a modest attempt was made to analyse the pattern of head injuries sustained on the victims of fall from different heights and is presented as a cross-sectional study.

Materials and Methods: The case study on the fatal incidents of fall from height was recorded and analysed statically in a sampling of one hundred cases which was subjected to detailed autopsy in a tertiary care hospital. In this analysis the nature and pattern of injuries, data regarding the nature of fall, the site of primary impact, period of survival and a detailed examination of head injuries were all noted. The statistical analysis was carried out using Microsoft Excel 2009.

Results: From the analysis, it is observed that the maximum number of fall from height cases seemed to be from the age group of 31 years ~40 years (30%) and males contributed to a majority of these cases (90%). Amongst head injury cases, 82% of the cases had intracranial haemorrhage and 10% had facial bone fractures. In the 82% of cases, 76% of cases had both subarachnoid haemorrhage and subdural haemorrhage. Also skull fracture was seen in 40% of the cases and the base of the skull fracture was noted almost equally in 37% of the cases. Injuries to head and cervical spine constituted to the salient features of primary head impacts, SAH alone is rare in such cases.

Conclusions: On the account of observation and analysis, it is noted that most of these cases were accidental in nature (93%) and Males (90%) in the age group of 31-40 years were in highest number (30%). Cranial injuries with subarachnoid and subdural haemorrhage seemed to be the most common cause of death amongst victims falling from heights. Also skull fracture were seen in 40% of the cases and base of skull fracture noted almost equally in 37% of the cases. While SAH alone in rare in these cases, injuries to head and cervical spine were the key impacts of primary head impacts.

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1. Introduction

Injuries due to falling from heights are the second most common unintentional accidents in the western world whilst motor vehicle collision stands first. There is an increase in the number of deaths due to fall from heights year on year as working from heights also increases day by day randomly due to modern urbanization. According to The International Classification of Diseases, fall from height is described as an event where a person falls to ground from upper levels whereas Frailty and Injuries Co-operative Studies of Intervention defines fall from height as unintentionally coming to rest on the lower most surface on the ground.

Depending on the height of fall, the fall can be distinguished as high and low falls which varies from multi-storeyed building to same or less-level falls like tables, chairs, ladder, flight of stairs etc. The nature of injuries sustained due to falling from height is directly dependent on the height of the body, weight of the body, special orientation of the body at the moment of impact, the nature of the surface impacted, force on which it hit the ground and the flexibility of part of the body at contact. Amongst this, the height of fall is the key factor of determination, cranial injuries are most common in fall from height cases which pose problems for the medico legal experts and investigators in arriving at conclusions about the manner of death.

A unique pattern of injury is observed among the victims of fall from height which depends on the inertia of the body, movement of the body, resistance of stationary objects and the nature of surface of ground on which the person falls.¹ During the fall, the falling body decelerates and the amount of kinetic energy is transferred to the point of contact on the site of impact and the ground thrusts an equal amount against the falling body itself. The energy is absorbed on the victim in the form of sustained injuries.²

With reference to Gordon and Shapiro, regardless of the position of landing for falls more than m there is a high incidence of deceleration injuries to intra thoracic and inter abdominal structure, especially where these are relatively immobile and tethered. For E.g., the aortic root and the mesenteric arteries⁴. Vertical deceleration injuries involve major weight bearing structures with forces transmitted through the foot, leg, pelvis and vertebral column.³

Also fall mechanisms and injury patterns are specific to the age groups too for instance falls at home decreases with age whereas falls at schools, colleges, sports and recreational events, the road traffic incidents increases with age. Most playground falls are due to falling to the ground surface and fractures are the most common type of playground related injury. Elbow, wrist and lower arm are commonly involved in nearly 80% of such cases, fatal head injuries are common in these cases too.

The reconstruction of the events acts as a clue in detecting the manner of death in the fatal cases of fall from height and the determination of probable anatomical site or area of primary impact to the surface is an important aspect. Cranial injuries with multiple blunt wounds on the head makes it hard to identify and distinguish the injuries caused due to the actual fall and those that were inflicted before the fall and disputes often arise regarding the height at which the death occurs. In this study, we aim to analyse the pattern of head injuries in such fatal cases of falling from heights.

2. Aim

To study the pattern of head injuries in fatal cases of fall from height.

3. Objectives

1. To assess the pattern of head injuries in fatal cases of fall from height with the primary site of impact.
2. To determine the cause of death in cases of fall from height.

4. Materials and Methods

4.1. Study design

Prospective Cross sectional study.

4.2. Study duration

1 year (August 2016 to August 2017).

4.3. Methodology

1. This study was carried out in a tertiary care hospital in Chennai and one hundred cases of fall from heights were subjected to detailed post-mortem examination.
2. Apart from recording the nature and pattern of injuries, data regarding the nature of fall, site of primary impact, nature of floor on which they fall, height from which they fall, period of survival etc., was obtained from the investigating officers. In all the cases, the height of fall was determined by visiting the scene of crime and taking measurements. Period of survival was calculated from autopsy findings and treatment records.
3. Special efforts were made to discover precipitating causes like epilepsy, mental illness, natural diseases and use of drugs or alcohol.
4. A detailed examination was made and data entered in a preform. Data includes external and internal injuries, their nature, dimensions and location.
5. Primary impact injuries were noted and photographs were taken wherever necessary. Blood and urine was collected and sent for analysis of alcohol or drugs if there were any suspicion. In case of treated patients, clinical data was entered.

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6. Autopsy was conducted by Letulle's method of an en masse removal of viscera and dissection of organs. This included detailed examination of external and internal injuries, their location, dimensions and nature.
7. For head injuries, on dissection of head, scalp, dura, vault, and base of skull were examined in detail. Brain was dissected carefully to look for all kind of haemorrhages like Extra Dural Haemorrhage (EDH), Sub Dural Haemorrhage (SDH), Sub Arachnoid Haemorrhage (SAH), Intra Cerebral Haemorrhage (ICH), and Inter Ventricular Haemorrhage (IVH). The areas with blood infiltration were cleaned with water, dissected and examined in detail to assess the nature and extent of injury.

4.4. Statistical analysis

All statistical analysis were carried out in Microsoft excel 2009 and the data were expressed in terms of percentage.

5. Results

Table 1: Distribution of study population according to head injury

| Head Injuries | No. of Persons in percentage (%) |
|--------------------------|----------------------------------|
| Scalp contusion | 31% |
| Skull fracture | 40% |
| Base of skull fracture | 37% |
| Brain laceration | 7% |
| Intracranial haemorrhage | 82% |
| Facial bone fracture | 10% |

Among head injuries, 82 cases had intracranial haemorrhage and 10 cases had facial bone fractures. Laceration in brain noticed in 7 cases.

Table 2: Distribution of study population according to type of intracranial haemorrhage

| Injury | No. of Persons in percentage (%) |
|-----------------|----------------------------------|
| SAH ALONE | 2% |
| SDH+SAH | 93% |
| SDH+SAH+EDH | 2% |
| SAH+SDH+EDH+ICH | 2% |

Extra Dural Haemorrhage (EDH), Sub Dural Haemorrhage (SDH), Sub Arachnoid Haemorrhage (SAH), Intra Cerebral Haemorrhage(ICH).

In victims who died of Head injuries, 76 cases had both subdural haemorrhage and subarachnoid haemorrhage. Along with the above extra dural haemorrhage was noted in 2 victims.

6. Discussion

This study was carried out at a tertiary care hospital, amongst victims from fatal cases of fall from height brought

Table 3: Distribution of study population according to spinal injuries

| Spinal Injuries | No of Persons in percentage (%) |
|-----------------|---------------------------------|
| Cervical | 26% |
| Thoracic | 7% |
| Lumbar | 3% |
| Sacral | 2% |
| Multiple | 1% |

to mortuary for a period of three consecutive years. There are mainly two types of injuries observed amongst victims falling from heights: Injury Resulting From Direct Impact (Mainly Fractures) and Declarative Type of Injuries. From our study and with inferences from previous works like Goonetillike et al,¹ the findings are consistent and it is found that the maximum number of fall from height cases were observed in the age group of 31-40 years (30%) and the least number of cases were in the age group of 0-10 years (1%). Males constituted to majority of the cases (90%) and the remaining were females (10%). Amongst the male victims it was also seen that 30% belonged to the age group of 31–40 years and 20% belonged to the age group of 41 -50 years. This study also indicates that the incidence occurred majorly between the daily wage labourers (34%) and the construction site workers (22%) which is slightly contrary to the other studies that indicate construction site workers are prone to fall from heights more. Students also contributed to about 10% of the cases, whilst it was found that in 58% of falls cases occurred in heights between 10 feet and 20 feet followed by 21% fall ranging between 0 to 10 feet of height. In the total number of cases, 93 cases were accidental (41 in home, 40 in workplace and other locations 12) and 7 were suicidal (5 in home and 2 in workplace).

The extent of the injuries in the body region and the frequency of the wounds were directly related to the height of fall and the primary impact. Both vault and base of skull can fracture with extrusion of brain when a person falls on the head. Head is the most common site of primary impact in majority of the cases (50%) which was evident from our study. In this study, most victims fell from high levels, and had landed on their head, striking the surface which resulted in more fatality as a result Peri-Orbital Contusion was observed in 11 cases. A certain range of injuries varying from scalp contusions to skull fractures, base of skull injuries, multitudes of intracranial haemorrhages like EDH, SDH, SAH, ICH were found in majority of the cases. The base of skull and vault fracture were witnessed in 37 and 40 cases respectively. As the height of the fall increases the audacity of the head injury is gruesome causing multilevel fractures involving skull and facial bones often with brain laceration and exoneration of the portion in brain parenchyma. Area of brain involved varies highly depends on the primary impact, striking

surface, direction of force involving coup and countercoup mechanism. Sacral spine was injured in 2 cases of pelvic fractures and associated bladder contusion seen in 1 case.

Fissured fracture of the skull and comminute fracture of the skull were noticed in 33 and 6 cases respectively. In 76 cases, subarachnoid haemorrhage and subdural haemorrhage were found which is relatively high in comparison to other cranial injury studies, fracture of facial bones (maxilla, mandible, nasal, lacrimal and zygomatic) was seen in 10 cases. 31 cases were seen with scalp contusion, however the extent of severity of the head injury does not depend on the scalp contusion because cases even without scalp contusion or mild contusion can still suffer internal injuries and vice versa. In most of these cases were victims fell (55%) and hit onto the hard surface (concrete) followed by mud and cement. Hard surfaces always cause serious injuries when compared to soft surfaces like sand, mud and grass. Brain and spine injuries are more common than fractures which is similar to that observation made in FRAILCO study. Multiple Organ involvement was noted when the nature of the ground was hard and isolated fatal injuries were common in the falls on soft surface.

In the spinal injuries, 26 cases showed Cervical Spine Injuries followed by Thoracic Spine Injuries which is contrary to the study mentioned, where the lumbar spine injury was predominating. Sacral spine injury was noted in 2 cases of pelvic fractures. Associated bladder contusion seen in 1 case. There is diverse demography amongst these accidents that occur amongst children to elders – fall could occur at work, at home or at recreational places. Some of the common risk factors contributing to it are risky behaviours, faulty equipment and absence of regulations. In men, alcohol poses a severe threat and is a serious risk factor since it is involved in 58% of SLF and 27% of HLF, also seen in women were 11% of SLF and 13% of HLF. With alcohol as the reason the injuries resulted showed varied patterns like more injuries prone to the face, brain and internal organs. The dose-response risk of falling compared to alcohol intake per day.⁴ Also evidences showed a history of alcohol intake in 28% of the cases. In a supplementary Greek study on fatal injuries there was 16% alcohol intoxication and 3.2% intoxication with other psychoactive drugs.⁵ In Sweden due to suicides by IHF, alcohol intoxication is present in 19%, which is less than other types of suicide.⁶

There were various external injuries noted in all types of the primary impact. In a similar study by Prathapan et al, intracranial bleeding was noticed in 63% of the cases and subarachnoid bleeding was the commonest among them (88%) followed by intracerebral bleeding. In this study, it was seen that 82% of the cases had intracranial haemorrhage had 76% had both subarachnoid haemorrhage and subdural haemorrhage.² In cervical vertebrae fracture case, blood seeps through the spinal meninges. Sheer strains could also

be the reason for subarachnoid bleeding. In all the primary head impact cases,⁷ cranial injury was the predominant factor, it still could have been due to secondary impact as well. In the current study, Brain damage was noted in 30 cases (56.6%) whereas the study by Prathapan et al showed (64%). In the other types of impact, injury to the brain was rare whereas in the present study brain injury was seen in all cases with intracranial bleeding, they were either contusions or lacerations.⁸ In the previous studies, 50% of the cases with spine fracture were associated with cord injury which is contrary to our study since only 25% of the cases had cord injury.² Due to the involvement of phrenic nerve in the upper cervical region, sudden death had occurred in victims with damaged cord.

Among the spinal injuries, cervical spine were injured in 26 cases followed by thoracic spine. This is in contrary to study mentioned where lumbar spine injury was predominating. In addition to head injuries, among thorax region injuries, rib fractures were noted in 32 cases, lung injuries noted in 5 cases, sternum and scapula were injured in 3 cases and diaphragm tear in 1 case. In this study, no cardiac injuries were noted. This may be probably due to the fact the primary site of impact, individual injuries sustained independently based on individual's deceleration force which is mass dependant and in majority of cases, head and back were the site of primary impact. Multiple abrasions all over the body were found in almost 90% of cases. Vertebral column fractures with associated spinal injuries were found in 36 cases since in this study, the second most common site of primary impact is back. However, multiple vertebral column were involved very rarely about 1 in 100 cases.

7. Conclusion

The study concludes that

1. Most cases of fall from height were accidental in nature (93%)
2. Males contribute to 90% of the study population amongst that 30% were in age group 31-40. Females are less prone to fall from height.
3. Head injury is the most common cause of death of the total cases, 82% of victims had intracranial haemorrhages, out of which 76% had both subarachnoid and subdural haemorrhages.
4. Facial bone fractures were least common (10%)
5. Skull fracture seen in 40% percent of cases and base of skull fracture noted almost equally in 37% of cases.
6. Injuries to head and cervical spine were the salient features of primary head impacts
7. SAH alone is rare in cases of fall from height
8. The study strongly recommends
 - (a) Detailed assessment and management protocol for at-risk people like elderly.

- (b) Balance training, regular muscle strengthening workout programs, home hazard assessment and management should be encouraged.
- (c) Individual targeted exercise programs following periodic assessment and follow up recommended.
- (d) Medication reviews and withdrawing from toxic medications that increase fall risk is strongly recommended.

8. Source of Funding

None.

9. Conflict of Interest

None.

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