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Original Research Article

Fall from Heights – Pattern of Injuries

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Abstract

Deaths due to fall from heights are common in the State of Kerala. Majority of the cases are falls from tall trees and buildings. The present study was conducted in the Department of Forensic Medicine, Medical College, Trivandrum. The objective was to find out the nature and pattern of injuries sustained to the victims of fall from heights. Effort was made to find out the height of fall by visiting the scene of occurrence. The site of primary impact was identified from the analysis of injuries, statements of witness and records of the police. Majority of the cases were accidental falls. Of the 100 cases studied, accidents constituted 98%. There were only two cases of suicide. Most of the victims were active laborers in the age group of 20-60 years and the height of fall varied from 5-10 meters. Maximum numbers of primary head impacts were also noted in this group. Apart from injuries to skull and brain, involvement of cervical spine was a common feature. Visceral injuries were a common feature in trunk impacts. Buttock impacts were characterized by fracture of pelvis and spine. Leg impacts showed fracture of leg bones and spine.

Keywords: primary impact, head impact, trunk impact, buttock impact, feet/leg impact, ring fracture.

1.Introduction

Death due to fall from heights are common in the State of Kerala. Majority of them are fall from tall trees and buildings. These cases pose problems for the medico legal experts and investigators in arriving at conclusions regarding the manner of death as reliable eye witness evidence will not be available. Therefore it is essential for the medico legal experts to analyze the nature and pattern of Injuries sustained to the victim to form a definite opinion as to the nature of fall. The pattern of injuries varies depending upon the site of impact as well as the height from which the victim had fallen[1]. A detailed autopsy and examination of the scene of occurrence can provide answers to the medico legal queries. An in-depth study has not been made in this subject in Kerala, where death due to fall from tall coconut and areca nut trees are very common[8]. There is no adequate literature available with reference to the type and pattern of injuries sustained

in cases of fall from heights. Therefore a modest attempt was made to analyze the pattern of injuries sustained to the victims of fall from different heights.

1.1 Aims and Objectives

1. To make a statistical analysis of 100 cases of fall from heights subjected to autopsy in the Department of Forensic Medicine, Medical College Trivandrum.
2. To conduct a detailed study of the pattern of injuries sustained to the victim in different types of impact.
3. To correlate the pattern of injuries with the primary site of impact.
4. To draw conclusions regarding the manner of death.

2. Materials and Methods

The present study was conducted in the Department of Forensic Medicine, Medical College

Trivandrum over a period of three years. One hundred cases of fall from heights which occurred in Trivandrum and neighboring Districts were subjected to detailed autopsy. Apart from recording the nature and pattern of injuries, data regarding the nature of fall, site of primary impact, period of survival etc. were obtained from the investigating officers. In all cases, the height of fall has been determined by visiting the scene and taking measurements. Special effort was made to find out precipitating causes like epilepsy, mental illness, natural diseases and use of drugs or alcohol.

A detailed examination was made and data was entered in a proforma. This included search for external and internal injuries, their nature, dimensions and location. Autopsy was conducted by Lettule's method of en masse removal of viscera and dissection of organs. After noting the visceral injuries, head chest, vertebral column, buttocks, upper and lower limbs were examined for primary impact injuries. The areas which showed infiltration with blood, the area was cleaned, dissected and examined to assess the nature and extent of injury. Photographs were taken wherever possible. Blood and urine were collected and sent for chemical analysis when there was suspicion of consumption of ethyl alcohol/drugs. In the case of victims who had undergone treatment prior to death, clinical data was also obtained.

3.Observations and Results

Of the one hundred cases of fall from height studied, 63 were fall from trees (63%) and 26 were fall from buildings (26%). The rest were fall into pits, fall from ladders and electric posts (11%)[9]. All cases of fall from trees were accidental (98%). Whereas two cases fall from buildings were suicidal (2%).Maximum number of victims (15) belonged to the age group of 40-49 years, (24%) and all were males. Of the 12 cases which belonged to the age group of 20-29 years, 11 were males and one was a female[5]. In the age group of 30-39 years, there were 20 males and one female. Between 50-59 years, there were 19 victims; 18 males and one female. Ten male victims were in the age group of 60-69 years.

Seven victims who belonged to 70-79 years age group were all males. There were only two cases in the age group of 80-89 years and both were males. There were no victims under the age of 10 or above the age of 89 years. In the present study, determination of the site of primary impact was difficult[4]. However based on the data obtained from the police, relatives and witnesses, as well as interpretation and evaluation of injuries, it was observed that in 53 cases, the primary site of impact was head. Trunk impacts were noted in 21 cases. Fifteen cases were buttock impacts and seven were leg impacts. Site of primary impact could not be determined in four cases.

Table 1: Fall from height – Sex Ratio

Sex	Fall from trees	Fall from Buildings	Miscellaneous	Total
Male	62	24	11	97
Female	1	2	0	3
Total	63	26	11	100

Table 2: Manner of fall

Fall from	Accident	Suicide	Homicide
Trees	63	-	-
Buildings	24	2	-
Miscellaneous	11	-	-
Total	98	2	-

Table 3: Age in relation to type of fall

Age in years	Trees		Buildings		Miscellaneous		Total		Percentage	
	M	F	M	F	M	F	M	F	M	F
0-9	-	-	-	-	-	-	-	-	-	-
10-19	2	-	3	-	-	-	5	-	5	-
20-29	6	-	3	1	2	-	11	1	11	1
30-39	10	-	9	1	1	-	20	1	20	1
40-49	15	-	5	-	4	-	24	-	24	-
50-59	12	1	2	-	4	1	18	1	18	1
60-69	10	-	-	-	-	-	10	-	10	-
70-79	6	-	1	-	-	-	7	-	7	-
80-89	1	-	1	-	-	-	2	-	2	-
Total	62	1	24	2	11	-	97	3	97	3

It has been observed that maximum numbers of falls were from a height of 5 -10 meters[2]. Number of cases which belonged to this category was 47 (47%). In 26 cases, the height of fall was 10-20 meters. The height of fall was below five meters in 25 cases. In the 20-30 meters range, there was only one case, which was a head impact. No case was observed in the range of 30-40 meters height. One case was found in the range of 40-50 meters height. There were no cases where height of fall exceeds 50 meters.

Primary head impact was noted in 28 cases[7] out of 63 cases of fall from trees (44.4%); while 18 head impact were noted in 26 cases of fall from building (69.23%). In the miscellaneous group of 11 cases, seven were head impacts (63.63%).

Primary trunk impact was seen in 17 out of 63 cases of fall from trees (27%), while only two cases noted in 26 cases of fall from buildings (7.6%). In case of fall from trees, 11 were primary buttock impact which constituted 17.46%, while in fall from buildings there were four cases of buttock impact (15.3%). There was no case of primary buttock impact in the miscellaneous group. Leg impacts were noted in five cases out of 63 cases of fall from trees (7.9%). One case each of primary leg impact was noted in 26 cases of fall from building (3.8%) and in the miscellaneous group of 11 cases (9.1%). The site of impact could not be determined in four cases, of which two were fall from trees; one was from building and the other belonged to the miscellaneous group.

Table 4: Pattern of impact in relation to the height of fall

Height of fall in meters	Head	Trunk	Buttock	Leg	Unknown	Percentage
0-5	16	3	2	1	3	25
5-10	25	10	9	3	-	47
10-20	11	8	4	2	1	26
20-30	1	-	-	-	-	1
30-40	-	-	-	-	-	-
40-50	-	-	-	1	-	1
>50	-	-	-	-	-	-
Total	53	21	15	7	4	100

Table 5: pattern of impact in relation to the type of fall

Type of impact	Tree	Building	Miscellaneous	Total	Percentage
Head	28	18	7	53	53
Trunk	17	2	2	21	21
Buttock	11	4	0	15	15
Leg	5	1	1	7	7
Unknown	2	1	1	4	4
Total	63	26	11	100	100

Different types of external injuries were noted in all types of primary impact[1]. External injuries to the head were noted in all the 53 cases of primary head impact. These injuries were abrasions, contusions or lacerations. At the same time 29 cases of head impacts showed external injuries on the trunk and 45 cases on the limbs. In all the 21 cases of primary trunk impacts, external injuries were mostly seen on the trunk. Nine cases in this group showed trivial external wounds on the head also. Trivial injuries to the limbs were noted in 17 cases. In 15 cases of buttock impact, external injuries were noted on the head (12cases), trunk (10 cases) and limbs (12 cases). In the four cases of unknown site of impact, external injuries were seen in the limbs. One case showed injuries on the trunk also.

Head injury was the predominant feature in all the primary head impact[6]. Head injuries were fractures of skull and various types of intracranial hemorrhages. In 53 cases of primary head impacts,

37 cases showed fractures of skull (69.8%). These fractures were either fissured (28 cases), comminuted (15cases) or depressed (4 cases). Fractures of mandible, maxilla and nasal bones were seen in 5 cases (9.4%). In 21 cases of primary trunk impacts, there was not even a single case of fracture of skull: but there were seven cases of intracranial bleeding. Out of the 15 cases of buttock impact, five cases showed fracture of skull (33.33%). Of these four cases showed comminuted fracture and one case showed fissured fracture. In one case of comminuted fracture, the base of skull was involved. There was only one case of skull fracture in the group of seven leg impacts (14.28%). In the four cases of unknown primary site of impact one case showed fissured fracture of skull (25%).

Different type of intracranial bleeding was noted in all types of primary impacts. Of the 100 cases studied, intracranial bleeding was present in 63 (63 %). Maximum incidence was in primary head

impacts (47 %). Subarachnoid bleeding was the commonest (88.47%). Subdural hemorrhage ranked next (62.26%). Intracerebral bleeding was noted in eight cases (15%). Six out of the eight were in the brain stem. In the 21 cases of trunk impacts, six cases showed intracranial bleeding. Seven cases of IC bleeding were seen among the 15 cases of buttock impact. Of the seven cases of leg impacts, IC bleeding was seen in two cases.

Brain substance was injured, in 34 out of the 53 cases of primary head impacts (64.15%). These injuries were either contusions or lacerations[7]. Out of the 21 cases of primary trunk impacts, there was only one case of laceration of brain. The skull was intact in this case. Three cases of injuries to the brain were noted among 15 cases of primary buttock impacts. These cases were also associated with fracture of skull. There was only one case of brain

laceration among the seven cases of primary leg impacts. No brain damage was noted among the group of undetermined site of impact.

In all types of primary impacts, injuries to the vertebral column and spinal cord could be observed. Of the 53 cases of primary head impact. 24 cases showed fracture of vertebral columns at various levels (45.3%). Of these, damage to the cord was noted in 15 cases (52.5%). Of the 21 cases of primary trunk impacts, fracture spine was in 14 cases (66.66%). Of these spinal cord was injured in eight cases. Fracture of vertebrae was seen in 12 cases of primary buttock impact (80%). Sacrum was found fractured in seven cases (66.66%). In the group of seven primary leg impacts, there were six cases of fracture spine. Cord was damaged in three cases. In the four cases of unknown sites of impact, fracture spine with cord damage was present in all.

Table 6: Injuries to Head and spine in relation to the site of impact

Primary impact	Number of cases	Fracture Skull	Intracranial bleeding	Injury to Brain	Injury to spine
Head	53	37	47	24	24
Trunk	21	-	6	1	14
Buttock	15	5	7	2	12
Leg	7	1	2	1	6
Unknown	4	1	1	-	4
Total	100	44	63	28	60

Fractures of various parts of the skeletal system were observed in all types of primary impacts. Clavicle ribs, sternum, humerus, forearm bones, femur, leg bones, calcaneum, foot bones and pelvis were found fractured. Fracture of the calcaneum (28.57%) and leg bones (28.57%) were a special feature of primary leg impacts. Fracture of pelvis was a salient feature in the 15 cases of buttock impact. It was seen in 14 cases (93.33%).

Visceral injuries were seen irrespective of the nature of impact. The most affected organs were the lungs and liver. In the present study of 100 cases of fall from heights, lung injuries were noted in 28 cases (28%). Liver was found ruptured in 9 Cases visceral injuries were more in trunk impacts (95%) and head impacts (37.7%), less in leg impacts (3 cases).

4. Discussion

One hundred cases of fall from heights were studied in detail and analysed. Generally the findings are consistent with the inferences drawn by the previous workers like Goonetillike et al[1]. The prime observation of this study is that the pattern of injuries depends upon the site of primary impact. It is revealed that serious injuries are sustained to the site

of primary impact. But injuries of varying nature are seen on other parts of the body also.

Majority of the cases were fall from tall coconut, areca nut and mango trees (63%). Workers while climbing the tees for collecting the produce fall accidentally and succumb to the injuries sustained. Most of the victims were in the age group of 20 – 30 years (69.84%) to which active labourers belongs to. There was only one female among the group, a house wife who climbed a cashew tree to pluck the nuts and fell from it. The next major group was fall from tall buildings (26%). The victims were construction workers in the age group of 20 – 60 years (87.5%).

The inference dawn from these findings is that death due to fall from heights in Kerala are common among labourers and the manner of death is accidental (93%). Suicides constituted only 2%. Similarly 97% of the victims were males. Studies conducted in UK and US reveal that commonest type of falls from heights is from high rise buildings. The victims belong to the age group of 1- 4 years and above 60 years.

The present study revealed that in the majority of cases, the site of primary impact was the head (53%). The present study revealed that the primary trunk impact constituted 21% of the total cases. Primary buttock impact ranked third in the

group (15%). Incidence of leg impacts were less in the present study (7%).

In the present study, height of fall varied from 3-45 meters. Majority of the victims (47%) had fallen from a height of 5-10 meters. Maximum numbers of primary head impacts were also noted in this group (55.3%). Primary trunk impacts ranked next (21.3%). Primary buttock impacts ranked third (15%) in the present study. Primary leg impact was only 7%. Primary head impacts showed the maximum number of head injury (69.3%). Fracture of skull was 69.3% in the primary head impacts. Another significant observation is that there were no fractures of skull in the group of primary trunk impacts. Fracture skull was only 26.6% in buttock impacts and 14.28% in leg impacts. Majority of the fractures were fissured fractures (65.9%). In the group of primary head impacts the percentage was 75.67. Majority of the fractures were extending to the base.

The extensive nature of the fractures can be attributed to the greater momentum developed in cases of fall from heights. The height of falls is a material factor in causing extensive injuries to head. This is evidenced by the presence of multiple severe injuries if the height of fall is more.

The present study showed intracranial bleeding in 63% cases. Subarachnoid bleeding was the commonest (63%). Very often it was seen not associated with fracture skull or injury to brain. If cervical vertebrae are fractured, blood can seep through the spinal meninges. Sheer strains can also be the cause of Subarachnoid bleeding. Seven out of 15 cases of buttock impacts showed intracranial haemorrhage. Head injury in primary impacts could have been due to secondary impact. Brain damage has been noted in 34 cases (64.15%) in the present study. In this group of primary head impact, brain damage was noted in 30 cases (56.6%) Injury to brain was rare in other types of impact. In the present study, brain injury was noted in all cases associated with intracranial bleeding.

Fracture of spine was seen in 60 cases of the present study. Maximum number of fracture spine was noted in primary head impacts (45.3%). The region most affected was the cervical spine (27%). Fracture of the vertebrae was usually due to indirect forces. The reason could be to the jackknifing of the torso resulting in flexion/extension of the spine at more than one site. Fracture spine due to direct impact has also been observed as evidenced by the presence of associated external injuries. In one case, fractures of the transverse processes of four upper cervical vertebrae were seen. This could be due to

torsion forces produced by the paravertebral muscles. Significant finding in the present study is that cervical and upper thoracic spines were involved in primary head impacts; while lower thoracic and lumbar vertebrae were involved in primary trunk impacts. Fracture of sacrum was a salient feature in buttock impacts. In leg impacts, cervical vertebrae were involved. This could be due to the transmission of forces through the vertebral column. In the present study, 50% cases of the fracture spine were associated with cord injury. Sudden death of the victims has occurred in cases where the cord was damaged in the upper cervical region due to involvement of phrenic nerve.

The present study revealed injuries to various parts of skeleton. Maximum number of fracture ribs was noted in primary trunk impacts (80.9%). Ribs usually affected were the 2nd to 10th. Fractures were seen at three sites; front, back and the posterior axillary line. The inference drawn is that the ribs are fractured due to direct impact. The side of trunk impact can be found out from the sites of rib fracture. Fracture of clavicle and sternum were also seen associated with rib fracture. Incidence of fracture of sternum was the highest in trunk impacts (19%). Sternal fractures were also associated with injuries to lungs and heart. This could be due to compression of the organs between sternum and spine. In primary buttock and leg impacts, fracture of sternum was rarely seen (only 2 cases).

Fracture of humerus, ulna and radius were also seen in the present study. There was no correlation with the primary site of impact; however the incidence was more in primary trunk impacts. Pelvic fractures were seen 17 cases. Of these 14 were in the primary buttock impacts (15 cases). This is a very significant finding. The inference drawn is that fracture pelvis is a clear indication of buttock impact.

Maximum number of fracture of femur was noted in primary leg impacts (71.4%). In one case, fracture of the shaft of femur was noted on one side and dislocation of the head of femur was noted on the other side. This finding is clearly indicative of primary leg impact. Primary head impact and trunk impacts showed only one instance of femur fracture. Fracture of leg bones was seen in only one case and it was a primary head impact. It could have been due to a direct impact. Fracture of calcaneum is an indication of feet impact. There were three cases and all of them were in the primary leg impact. Laceration of heel has also been noted in such cases. Fracture of metatarsal and phalanges were also seen in primary leg impacts.

Visceral injuries were seen in 55 cases. Irrespective of the nature of primary impact, various injuries to internal organs like lungs, heart, liver, spleen, intestines and urinary bladder are sustained. However maximum number of lung injuries was in the group of trunk impacts. Rupture of heart and aorta were seen in four cases of fall from a height more than 15 meters. Deceleration injuries of heart and aorta were seen in primary feet and buttock impacts. Maximum incidences of liver injuries were seen in primary trunk and buttock impacts. Spleen was found ruptured in four cases; two of this belonged to primary trunk impacts. Injury to kidneys was very rare. There was only one case in the present study and that was a buttock impact. It was associated with fracture of ribs. These findings indicate that injury to the kidney was as a result of direct impact.

5. Summary and Conclusions

- 1) Majority of the cases are fall from tall trees and buildings.
- 2) The victims were mostly male labourers and construction workers in the active age group of 20- 60 years.
- 3) Maximum number of cases was seen in fall from heights ranging from 10 – 20 meters.
- 4) Primary site of impact could be identified and confirmed from the pattern and nature of injuries.
- 5) Primary head impact is the commonest type; trunk impact ranks next, followed by buttock and leg impacts.
- 6) Maximum incidence of primary head impact was in the falls from buildings.
- 7) Maximum incidences of trunk impacts were in the case of falls from trees.
- 8) Injuries to head and cervical spine were the salient features of primary head impacts.
- 9) Injuries to spine, ribs sternum and viscera are the features of primary trunk impacts.
- 10) Fracture of pelvis and sacrum are the hall marks of primary buttock impact.
- 11) Manner of death in the majority of the cases are accidental.

References

- [1] Goonetilleke Albert. Injuries caused by fall from height, *Journal of Medicine Science and Law* 1980; 20 (4): 262-264.
- [2] Buckman R F. Vertical deceleration trauma. *Surg Clin. North America* 1991; 71 (2): 331-344.
- [3] Gupta S M et al. Blunt force lesions related to the height of fall. *Am. J. Forensic Med. Pathol* 1982; 3(1): 35 - 43.
- [4] Mac Laughlin H L, Trauma. W. B Saunders Company, Philadelphia, 1960: p 146 -571
- [5] Mason J K. Paediatric Forensic Medicine and Pathology 1989; 1st Ed p 314, Chapman and Hall, London.
- [6] Rajaram N A. Correlative study of type of impact and nature of injuries sustained to head - unpublished thesis. 1988
- [7] Rufus C. Closed head injury, its pathology and legal medicine 1985; 1st Ed Edwrd Arnold London p 21-26.
- [8] Sreekumari K A. Study of Medicolegal aspects of abdominal injuries – unpublished thesis.
- [9] Tedeschi C G et al. Forensic Medicine, A study Trauma and environmental hazards 1977; Vol 1 Mechanical trauma p 886 1168, MB Saunders, Philadelphia.
- [10] Watson J. Fracture and joint injuries 1982; 7th Ed p 749 Churchil Livingstone New York.