Autopsy Based Study on Injury Pattern and Socio Demographic Profile in Victims of Fall from height into Water

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ABSTRACT

Back ground and objectives: *Fall from height in to water with mention of injuries, were included in the international classification of diseases (ICD) as fall from height. Severity of the injuries depends on various biological and circumstantial factors. This study was taken up with the objective to describe the pattern of injuries and socio- demographic profile of victims of fall from height into water with mention of injuries.*

Method: *Descriptive autopsy based study on 53 cases of fall from height into water with any mention of injuries conducted at State Medico legal Institute, Medical College, Thiruvananthapuram, Kerala during the period from May 2006 to April 2008.*

Results and interpretation: *Majority of victims were males (69.8%). Age ranged from one year one month old female child to 90 years old elderly female. Incidence was maximum in lower and lower middle income group (88.7%). Place of incidence was home in 66% of cases. Accidental death constituted 50.9%. Majority died due to fall into well (88.7%). Significant number of victims fell down from a height range of 5 to 10 meters (39.6%). Drowning was the foremost cause of death irrespective of height of fall (58.5%). External injuries were invariably present in all cases and internal injuries in 41.5%. Most frequent region involved was head in 33.9% cases. Injury severity was not proportional to the height of fall.*

Conclusion: *Falls are extremely common, the severity not necessarily being directly related to the distance that the person falls. Along with other factors, surface of impact also plays a major role in determining the severity of injuries in cases of fall from height.*

Key words: *Fall from height into water, Injury pattern, Surface of impact, Autopsy study.*

INTRODUCTION AND BACKGROUND

Fall from height in to water with any mention of injury except those resulting in drowning or submersion without injuries, were included in the ICD classification as fall from height[1]. If a person falls jumps or is thrown into water he may suffer all kinds of blunt injuries from protruding objects, such as a rock, a ship's side, a pier and so on before he reaches the water. In the water also a number of injuries may occur[2]. Occasionally, extensive and severe internal visceral and skeletal injuries may occur in the absence or near absence of any significant external injury, when the body lands upon a relatively 'soft' surface such as a grass patch or a body of water(such as swimming or landscape pool)[3].

Theoretically it should be possible to correlate the height of fall with the severity and extent of the injuries sustained. Although Knight (1996)[4] has said that it is extremely difficult to the point of impossibility, to deduce the height of the fall from the nature and severity of the injuries because it depends on biological and circumstantial variables.

Mechanism of injury production can be explained mainly under the following headings[, 5,6]

1. Velocity of fall: In fall from height the rate of change of the direction and speed of movement that result in tissue injury. Assuming that the victim had been subjected to vertical free fall, then often extensive and severe injuries sustained by them would largely be the consequence of their bodies coming to an abrupt halt upon impact with the ground or some other structure and absorbing the forces of deceleration [3, 6].

2. Rate of energy release: If the kinetic energy is discharged slowly enough to overcome the inertia of the tissue mass as a whole and to impart a relatively uniform motion to it, it will fail to produce a wound [5,6.]

3. Elastic property of surface of impact: The surface on to which a body falls determines the pattern of deceleration and energy discharge. On a relatively yielding surface such as soft net or water the energy is given slowly, but on a relatively unyielding surface such as concrete, time of deceleration is less, so forces on the body will be much greater[7]. The magnitude of the accompanying forces of deceleration may best be appreciated by considering the corresponding G forces (gravities) which measure the rate of change of movement[4,8] .

In most studies the victims landed on hard, unyielding concrete surfaces in the most majority of cases. It was not possible to determine the momentary deformation that these structures might have undergone after impact. The concrete structures upon which the bodies landed remained largely intact after the fall. It is clear that the value of 'G' is inversely proportional to the stopping distance that is

the more resistant the area of surface of impact, the greater is the deceleration forces. The range of G forces corresponding to a deformation of 1 cm would be about 1910 – 3900 G, while that for 5 cm would be 380 – 780 G[4,8]. In case of falling in to water even though the swimmer or scuba driver experiences 1 g (full weight) buoyancy largely cancels weight of the body.

4. Area of contact: Orientation of the body at the point of impact is important in determining injury pattern and mortality[7]. The wound producing potential of energy depends on the area of impact.

5. Other factors such as hydraulic ram effect, resulting from the upward forceful acute displacement of the abdominal organs and consequent cardiac injury in the absence of direct thoracic trauma[5]. All these mechanisms shows that injury sustained during free fall depends on many factors such velocity of fall, rate of energy release, nature of the landing surface and the body orientation of landing. Surfaces such as mud, snow, soft earth water can permit an increased duration of impact, reducing deceleration forces and hence injuries sustained. For an average man, a 5 m fall on to a concrete surface produces a deceleration force of approximately 700 gm, but if the landing is into a soft, yielding surface the stopping distance may be several centimeters, decreasing the force 10 to 20 fold [9].

There is a relative paucity of published scientific literature on the pathology of trauma resulting from falls from height into water, particularly in relation to pattern of injury and injury severity. The study was taken up with the objective to describe the pattern of injuries and socio-demographic profile of victims of fall from height into water with mention of injuries.

MATERIALS AND METHODS

This was a descriptive study conducted during the period from May 2006 to April 2008 including all fatal cases of fall from height into water with mention of injuries brought for autopsy at State Medico legal Institute and Department of Forensic Medicine, Medical College, Thiruvananthapuram, Kerala, India. The study sample comprised of 53 cases of fall from height into water with injuries. (ICD 9 and ICD10)[1]. Victims of fall from height on to land, fall from moving vehicle, fall from standing height, decomposed bodies and unknown bodies were excluded from the study. The study was conducted after obtaining institutional ethical committee clearance. Study was autopsy based and fully anonymous. Personal details were not revealed. Data entered in Epi info statistical package and analysis done using Epi info statistical package and Microsoft Excel work sheet.

RESULTS

Age and gender distribution

Among 53 cases, 69.8% were males and 30.2% were females. Age ranged one year one month old female child to 90 years old elderly female, both of them fell down in to well, accidentally. Peak incidence (22.6%) noted in the age group of 30 to 40 years followed by 20.8% in the age group of 40 to 50 years (Table:1).

Table: 1. Distribution of cases according to age and sex

Age group in years	Number			Percent
	Male	Female	Total	
≤ 10	2	1	3	5.7
10-20	1	1	2	3.8
20-30	3	0	3	5.7
30-40	9	3	12	22.6
40-50	8	3	11	20.8
50-60	6	1	7	13.2
60-70	5	3	8	15.1
70-80	3	3	6	11.3
80-90	0	1	1	1.9
Total	37	16	53	100

Occupation

Best part of victims were manual laborers (34.0%) followed by unemployed persons (15.1%) and house wives (13.2%) (Fig:1).

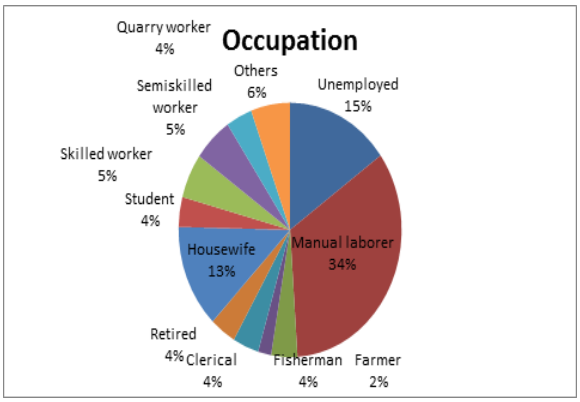

Fig. 1: Distribution cases according to occupation

Socio economic status

Most of the victims completed school level studies (81.1%). Incidence was maximum in lower and lower middle income group (88.7%) and the rest by upper class (11.3%). In this series, 41 (77.4%) were married and rest of the victims were unmarried (20.8%) except for one. Majority was moderately nourished (83%), 1.9% were well nourished and 15.1% were poorly nourished.

Period of survival and complications

Among the victims 94.3% died on the spot or were brought dead to hospital. Two persons

survived less than 6 hours and only one person survived more than 3 days and developed pneumonia.

Prevalence of illness or addiction

In the study sample, 10 cases (18.9%) showed addition to alcohol/drugs. Five (9.4%) had some organic disease and fell down from height accidentally or jumped from height to end their life. Psychiatric illness was found 7 cases (13.2%) (Fig:2).

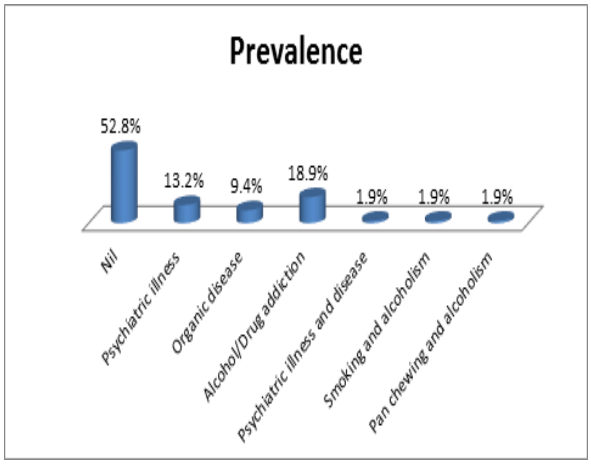

Fig: 2: Prevalence of illness or addiction among victims

Place of incidence and manner of death

In 35 cases (66%) incident happened at home and in15 cases (28.3%) at other places, only 3 persons died at work site. Accidental death constituted 50.9%. Suicidal deaths were 32.1%. Homicidal fall was seen in 3.8%. In rest of the cases manner of death was uncertain (Table.2).

Table: 2. Place of incidence and manner of death

Place of incidence.	Accidental	Suicidal	Homicidal	Uncertain	Total (%)
Home	16	14	0	5	35 (66.0)
Work place	2	0	0	1	3 (5.7)
Others	9	3	2	1	15 (28.3)
Total	27 50.9%	17 32.1%	2 3.8%	7 13.2%	53 (100)

Site of fall

Majority died due to fall into well (88.7%) all other sites together constituted only 11.3 %(Fig: 3).

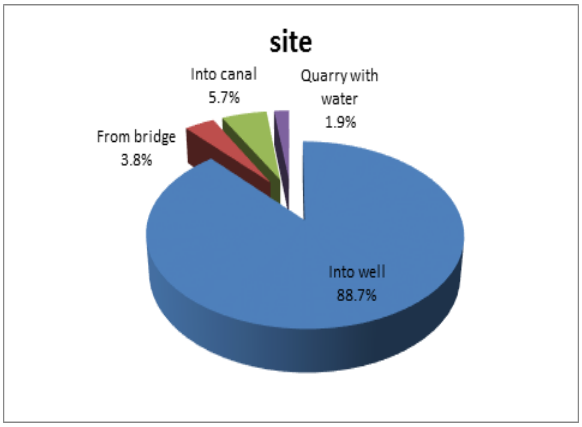

Fig: 3: Distribution of cases according to site of fall

Height of fall

Table: 3. Distribution of Height of fall

Height (meter)	Number	Percent
Less than 1	0	0
1 – 5	6	11.3
5 – 10	21	39.6
10 – 15	11	20.8
15 – 20	12	22.6
20 – 25	1	1.9
25 – 30	0	0
30 – 35	0	0
35 – 40	0	0
40 – 45	0	0
45 – 50	1	1.9%
More than 50	1	1.9%
Total	53	100.0%

In this series, 39.6% fell down from a height range of 5 to 10 meters. All except two fell down from height less than 25 meters (Table: 3).

Cause of death

Table: 4. Distribution of cases according to cause of death

Cause of death	Number	Percent
Head injury alone	1	1.9%
Drowning	31	58.5%
Drowning & injury	20	37.7%
Drowning and poisoning	1	1.9%
Total	53	100.0%

Most number of victims died as a result of drowning (58.5%). Head injury alone and combined effects of drowning and poisoning constituted one case each. Rest of victims died due to combined effects of drowning and injury (37.7%) (Table: 4).

External injuries

External injuries were invariably present in all cases in one or other region. They ranged from minor abrasions to lacerated puncture wounds.

Abrasions were most frequently seen in extremities and contusions and lacerations in head region. Head region showed maximum number and types of injuries.

Internal injury

Internal injuries were present in 22(41.5%) of cases and were absent in rest of the cases. Most common region involved was head in 18 cases (33.9%), head alone in 14 cases (26.4%) and combined with other regions in 4 cases (7.5%). Chest was involved in 4cases (7.6%), alone in 2 cases and in combination with other regions in 2 cases.

Fracture of skull was present in 6 cases (11.3%). Most common type of fracture skull was depressed fracture of vault with fracture of base seen in 2 cases (3.8%). Brain injury was present in 6 cases (11.3%).Contusion was the most common type of brain injury constituting 9.4%. Intracranial hemorrhage was seen in 17 cases (32.1%). Subarachnoid hemorrhage found in 10 cases (18.9%) which was the most common type of isolated hemorrhage. Subdural and subarachnoid hemorrhage together found in 6 cases (11.3%). Dural tear was found only in 1.9%. Raised intracranial tension was seen in 24.5%. Most frequent combination of head injury was brain injury and intracranial hemorrhage (11.3%).

Ribs were found fractured in 4 cases (7.6%). Ribs were fractured on right and left side in 2 cases each. No Fracture of sternum or clavicle or injury to lungs found in the study. Heart showed injury in one case in form of contusion of left ventricle. Only 2 cases (3.8%) showed hemothorax.

No abdominal visceral injury was present in any of the cases except contusion of mesentery and contusion of lesser sac in one case each. Fracture separation of cervical vertebral column between C4-C7 with laceration of spinal cord underneath was present in one case (1.9%). None of the victims had fracture of pelvis or extremities(Table:5).

Table: 5. Distribution of Internal injuries

Region	Number	Percent
No injury	31	58.5
Head alone	14	26.4
Chest alone	2	3.8
Spine alone	1	1.9
Head + other regions	4	7.5
Chest + other regions	2	3.8
Abdomen + other regions	1	1.9
Spine + other regions	1	1.9

DISCUSSION

Fall from height is a major problem of low socio economic and low educational group. Illness or addiction had a role in some cases. Significant number (16) died accidentally at home. Majority fell down in to well (88.7%).

Even though external injuries were present in all cases, internal injuries were found only in 22 cases (41.5%). Most common region involved was head in18 cases. Chest injuries were confirmed to rib fracture in 4 cases, contusion of heart in 1 case and hemothorax in 2 cases. Injury to abdominal viscera and spine was found only in one case each. No injury to major blood vessels, pelvis or extremities was present in this series.

Table: 6. Height of fall with respect to internal injuries and Cause of death

Height (metres)	Number of cases	Internal injuries		Cause of Death		
		Present	Absent	Drowning	Drowning & injuries	others
1-5	6	2	4	4	2	0
5-10	21	7	14	13	8	0
10-15	10	4	6	7	2	1
15-20	13	7	6	6	6	0
20-25	1	1	0	0	0	0
Total	51	21	30	30	20	1

In the present series even though 88.7% of victims fell down from a height of more than 5 meters majority died due to drowning alone (58.5%), followed by drowning and injury (37.7%), injury alone caused death on only one victim in the form of head injury. On detailed analysis, out of 53 victims all except 2 fell down from a height less than 25 metres. Out of these 51 cases 30 had no internal injuries and all of them died of drowning. One who fell down from more than 45 metres died of drowning alone and the other one who fell down from more than 50metres died of drowning and chest injury (Table: 6).

According to Gordon and Shapiro, regardless of the position on landing, however, for falls more than 5 m there is high incidence of deceleration injuries to intra thoracic and inter abdominal structures, particularly where these are relatively immobile or tethered – for example the aortic root and the mesenteric arteries[9]. Another literature review (Robertson C.E) shows that the major determinant of injury and the changes of death directly proportional to the height fallen, as the accelerating force of the gravity is constant. At impact the deceleration forces are determined by the individual deceleration – mass and the nature of the landing surface and the body orientation of landing. Surfaces such as mud, snow, soft earth and to a lesser extent, water can permit an increased duration of impact, reducing deceleration forces and hence injury. For an average man, a 5 m fall on to a concrete surface produces a deceleration force of approximately 700 gm, but if the landing is into a

soft, yielding surface the stopping distance may be several centimeters, decreasing the force 10 to 20 fold [10].

But in the present study, injuries sustained by the victims who fell down into water were not proportional to the height of fall. As described in various literature this disparity could be due to the following mechanisms (1) falling on a relatively yielding surface such as soft net or water, the energy is released slowly, but on a relatively unyielding surface such as concrete, time of deceleration is less, so forces acting on the body will be much greater[7,10] (2) 'G' force is inversely proportional to the stopping distance after impact, that is in water the victim's stopping distance is more than that of a concrete surface. (3) Buoyancy of the water largely cancels weight of the body[4,8.]

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CONTRIBUTORSHIP

Saritha S. R designed the study, conducted the literature research, collected data, conducted analysis, interpreted the results and wrote all drafts including for publication. K. Sasikala contributed to data analysis, interpretation of results, literature review and in preparation of the version to be published.

ETHICAL CONSIDERATION

The study was conducted after obtaining institutional ethical committee clearance. Study was autopsy based and fully anonymous. Personal details were not revealed.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest real and perceived.

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