

An Elucidation of Pattern of Injuries in Patients with Fall from Height

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ABSTRACT

Background: Fall from height (FFH) is the second most common cause of trauma presenting to the emergency department (ED). They account for majority of the polytrauma cases. This study was done to determine the pattern of injuries sustained due to FFH and outcome.

Materials and methods: This was a retrospective observational study of all patients with history of FFH presenting to the ED of a large tertiary care hospital in South India. Details of the incident, fall height, injuries, and outcome were noted and analyzed.

Results: This study cohort included 861 patients with a mean age was 36.2 (SD 20.8) years. A male predominance (74%) was noted. Majority of the patients, i.e., 62%, were triaged as priority 2, depending on the hemodynamic stability. Approximately a quarter (26%) sustained injury to the lower limbs with 18% sustaining spinal cord injury (SCI). Among the patients suffering SCI (35%), patients were further categorized in the American Spinal cord Injury Association (ASIA) classification. New Injury Severity Score (NISS) was more than 8 in 47% of the total study population. Majority of the patients, i.e., 62%, were discharged stable from ED after primary care with a plan of follow-up in the outpatient department. One-third (30%) of the total patients required hospital admission and among them 20% of the patients had to undergo major surgical intervention. The rest were either discharged stable or left against medical advice (LAMA) after primary care. The in-hospital mortality rate was 1.04%.

Conclusion: This study has expressed the pattern of injuries in patients with FFH. An alarmingly high number of young adults with significant lower limbs and spinal injuries were noted. We observed that with increase in fall height there was a proportional increase in SCI and decrease in lower limb injuries.

Keywords: American Spinal Cord Injury Association classification, Emergency department, Fall from height, Spinal cord injury, Trauma.

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INTRODUCTION

Fall from height (FFH) is defined as an injury to a person that occurs after landing on the ground after falling from a higher place, such as a ladder, scaffold, building, roof, or other elevated place or work area.^{1,2} The pattern of injuries in cases of falls from heights is dependent on the height, body weight, velocity, nature of surface impacted, orientation of body at the moment of impact, and the elasticity and viscosity of tissue of the contact body region, out of which height of fall is the major determining factor.^{3,4} Globally, FFH is a substantial public health jeopardy and is among the leading causes of serious and fatal injuries.⁴⁻⁶ Among patients with trauma, FFH is the second most common cause of injury-associated mortality after road traffic accidents in India.⁷ Literature review from the West suggests that the injuries caused by falls are more likely to be life-threatening than most other types of injuries.^{8,9} These incidents mainly include occupational accidents in the construction industry and may lead to permanent disabilities and a high rate of fatalities. In India, especially in the rural areas fall from tree is a major cause of such injuries and is a serious occupational hazard for many subsistence farmers. In the rural parts of our country where roads and ways of commuting are difficult, the so-called "golden hour" of trauma is lost, even though there is a potential mortality and morbidity reduction if first aid was administered to these victims.¹⁰ Patients with these injuries whether open or closed, spine, blunt injury to abdomen or thorax or brain need urgent assessment and treatment to reduce the risk of acute or chronic complications.

This study was done to describe the patterns of injury seen in FFH and to look at the correlation between the height from which

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fall has happened and types of injury with a special emphasis on spinal cord injury (SCI). This is one of the few studies on FFH, which focuses on the profile of injuries based on the fall height victims in India.

MATERIALS AND METHODS

Design

The study was a retrospective study conducted in the ED of Christian Medical College Hospital, Vellore.

Setting

The adult ED is a 49-bed department and tends to about 300 patients per day including trauma and nontrauma patients.

Participants

Our study recruited all patients presenting with trauma following FFH during the study period of 24 months (January 2017–December 2018).

Study Size

To determine the pattern of injury in FFH, we recruited patients from the 2-year period. The total number of patients were 897 who presented to ED in the study duration, of which 861 patients were included in this study.

Exclusion Criteria

Charts with incomplete data.

Variables

The charts were reviewed, and the relevant details of history, clinical examination, and laboratory and radiological investigations were documented in the study form. Further, the severity of injury in terms of New Injury Severity Score (NISS) and outcome of each patient were noted from immediate resuscitation to conservative/surgical management. Triage of these victims was done by the standard Canadian triage system according to which the sickest patients with hemodynamic instability are classified as priority 1 with priority 3 being more stable patients.

Outcome Variable

Outcomes of the patients from the ED with regards to admission, discharge, leave against medical advice (LAMA), and death were documented. The other variable noted was long bone injury and SCI.

Bias

This is a retrospective study, and therefore we could not control exposure or outcome assessment, and instead relied on others for accurate recordkeeping.

Laboratory Test

All patients had relevant radiological tests and routine blood investigations based on the initial primary and secondary surveys.

Statistical Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) for Windows software released 2015 (version 23.0, Armonk, New York, USA). Data were summarized using mean along with standard deviation for continuous variables and frequencies along with percentages were calculated. Some of the variables such as sex of the patient, occupation of the patient, and mode of injury were categorized and coded. A bivariate analysis was done to identify the relationship between these variables and the potential determinants. All possible determinants with $p \leq 0.05$ in the bivariate analysis were used as candidates for the multivariate analysis. Determinants identified in the bivariate analysis were entered into a multiple logistic regression model to determine their significant association simultaneously.

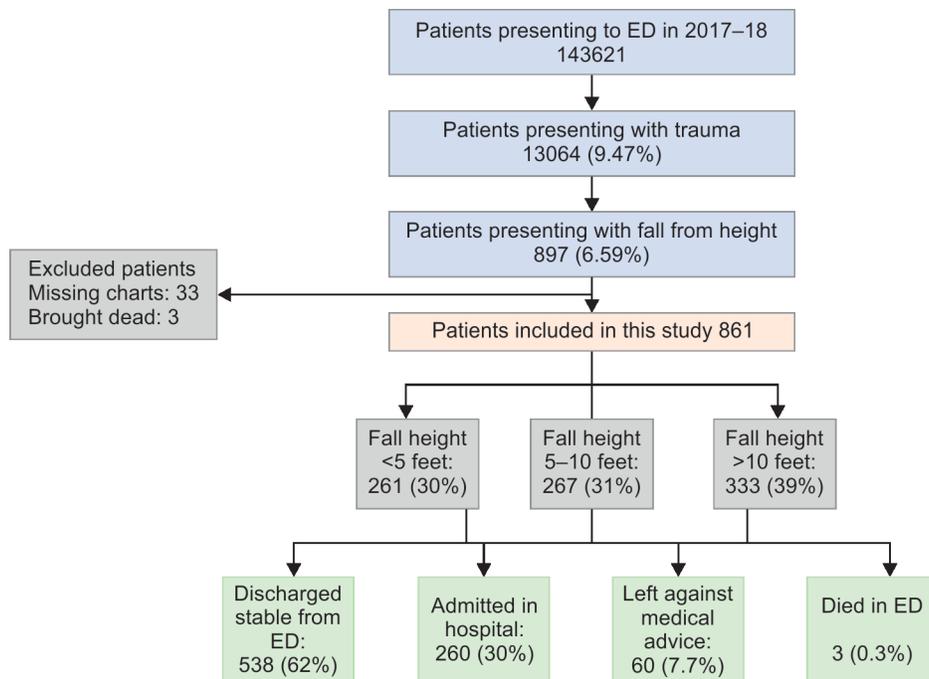
Ethical Considerations

This study was approved by the institutional review board. Prior to the commencement of the study, approval from the institutional review board ethical committee was obtained (IRB Min no: 12222 dated August 22, 2019). Patient confidentiality was maintained using unique identifiers and by the password-protected data entry software with restricted users.

RESULTS

A total of 143,621 patients presented to the ED during the study period with trauma victims comprising 9.47% (13,604). Among these trauma patients, 861 (6.3%) patients presented with FFH (Flowchart 1). These patients’ charts were screened and analyzed for the study.

Flowchart 1: STROBE diagram



Demographic Profile

Male predominance was observed as expected with 74% patients with a mean age of 36.2 (SD 20.8) years. The baseline characteristics and vital signs at presentation are given in Table 1. The triage priority was classified based on the Glasgow Coma Scale (GCS), hemodynamic stability, and severity of injury. The triage priority distribution of patients is as follows: priority 1 (14%), priority 2 (62%), and priority 3 (24%).

Injury Profile Based on Fall Height

The patients were classified into three groups, less than 5 feet, between 5 feet and 10 feet, and more than or equal to 10 feet, respectively, based on their fall height for the purpose of analysis.

Table 1: Baseline characteristics and vitals at presentation

Variables	Frequency (n = 861) (%)
Age, mean (SD) years	36.2 (20.8)
0–18 years	160 (18.6)
19–35 years	268 (31.1)
36–50 years	212 (24.6)
>50 years	221 (25.7)
Sex	
Male	640 (74)
Female	221 (26)
Fall height (in feet)	
<5	261 (30.3)
5–10	267 (31.1)
>10	333 (38.6)
Vitals at presentation	
SpO ₂ <94%	71 (8.2)
Systolic blood pressure (mm Hg) <100 mm Hg	99 (11.5)
No head injury GCS 15/15	808 (93.9)
Mild head injury GCS 13–15	12 (1.4)
Moderate head injury GCS 9–12	8 (0.9)
Severe head injury GCS 3–8	33 (3.8)

GCS, Glasgow coma scale

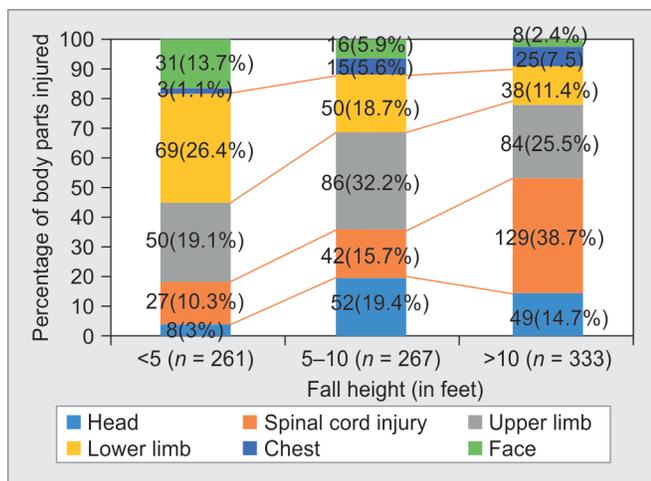


Fig. 1: Regions of body involved based on fall height

Approximately one-quarter (26%) patients sustained injury to the lower limbs followed by the spinal cord (18%). Body parts injured with respect to fall height are represented in Figure 1. More than half (54.6%: 65/119) of the priority 1 patients and a third (32.7%: 175/535) of priority 2 patients had a NISS of more than 8. The mean NISS in patients categorized by fall height is as follows: <5 feet: 4.39; 5–10 feet: 7.91; and ≥10 feet: 13.64. Distribution of triage priority levels and the body parts injured are shown in Table 2. It was noted that with increase in height, there was a proportional increase in SCI. These patients with SCI were further categorized in the American Spinal Cord Injury Association (ASIA) classification. Among the patients with SCI, the lumbar spine was the most involved region and was seen in 65 (40%) patients, followed by the thoracic spine in 54 (33%) patients and the cervical spine in 51 (31%) patients. The profile of these injuries is detailed in Figure 2.

Factors Associated with Severity of Injuries

Bivariate and multivariate logistic regression analysis for factors associated with FFH showed significant risk of calcaneal, spine, and pelvis fractures in victims who had a fall height of more than or equal to 10 feet. Unadjusted, adjusted odds ratio (OR) and *p* values of each of these variables are given in Table 3.

Management, ED, and Hospital Outcome

The ED team alone treated and discharged around 60 (6.9%) of the total study population, while the remaining required evaluation and treatment by various trauma surgical teams. The trauma specialties that were involved were orthopedic surgery in 332 (38.5%) cases, neurosurgery in 187 (21.7%), trauma general surgery in 82 (9.5%), plastic surgery in 77 (8.9%), hand reconstruction surgery in 31 (3.6%), spine surgery in 52 (6%), ENT in 12 (1.3%), and cardiothoracic surgery in 30 (3.4%).

Most of the patients, i.e., 538 (62.4%), were discharged stable from the ED, among which 120 (13.9%) were taken up for minor emergency procedures like wound wash, debridement, suturing, or nailing of the fractures in the minor theater of the ED itself. Thirty percent of patients (260) required immediate hospital admission, among which 169 (65%) patients had to undergo major surgical interventions and the rest were managed conservatively (Table 4). Majority of these admitted patients, i.e., 250 (96%), were discharged from the hospital in a stable hemodynamical condition. Three patients (0.3%) succumbed in the ED during resuscitation and six (1.04%) patients succumbed during the hospital stay.

DISCUSSION

Our study on FFH showed that calcaneal fractures, pelvis fractures, and SCI have a higher odds with increasing fall height. The severity

Table 2: Triage priority level and regions of the body involved

Variables	Frequency (n = 861) (%)		
Body parts involved	Priority 1 (n = 119) (14%)	Priority 2 (n = 535) (62%)	Priority 3 (n = 207) (24%)
Face	16 (13.4)	67 (12.5)	29 (14.0)
Head and neck	50 (42.0)	92 (17.2)	6 (2.9)
Thorax	47 (39.5)	78 (14.6)	15 (7.3)
Abdomen	26 (21.9)	53 (9.9)	8 (3.9)
Extremities	46 (38.7)	266 (49.7)	111 (53.6)
Skin and soft tissue	46 (8.7)	109 (20.4)	37 (17.9)

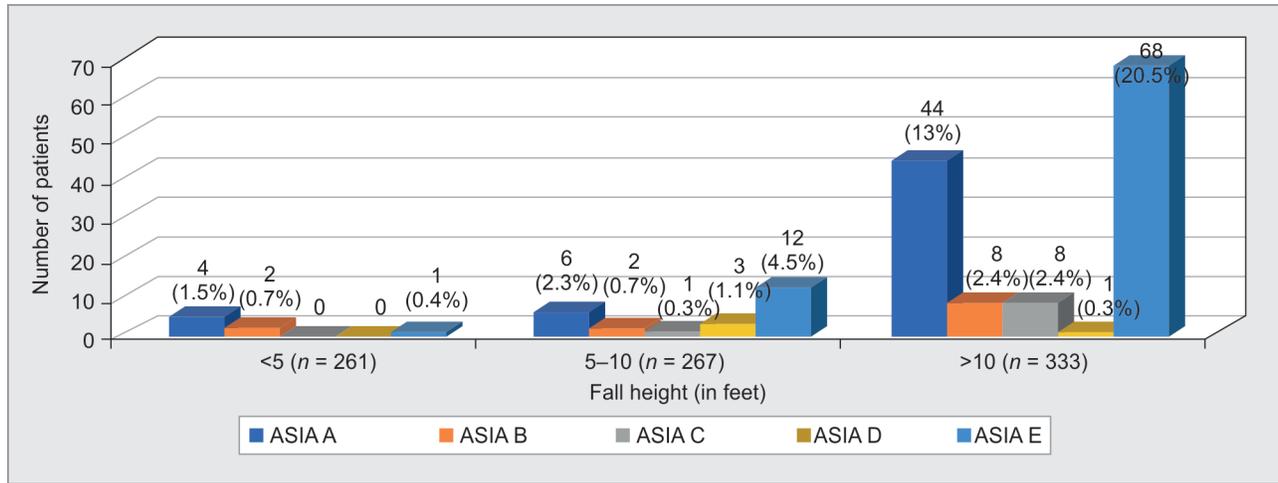


Fig. 2: Severity of SCI

Table 3: Bivariate and multivariate logistic regression analysis for factors associated with fall height specialities ≥10 feet

Variable	Fall height (in feet)		Bivariate analysis		Multivariate analysis	
	≥10 feet	<10 feet	Unadjusted OR (95% CI)	p value	Adjusted OR (95% CI)	p value
Calcaneal fractures	28 (8.4%)	8 (1.5%)	5.98 (2.69–13.30)	<0.001	6.45 (2.78–14.93)	<0.001
Spinal injuries	130 (39.0%)	31 (5.9%)	10.26 (6.71–15.69)	<0.001	10.60 (6.89–16.31)	<0.001
Pelvis	22 (6.6%)	6 (1.1%)	6.15 (2.46–15.34)	<0.001	6.53 (2.49–17.13)	<0.001

Table 4: Correlation between height of fall and need for procedure

Characteristics	Fall height <5 feet (n = 261), frequency (%)	Fall height 5–10 feet (n = 267), frequency (%)	Fall height >10 feet (n = 333), frequency (%)
Conservative	206 (78.9)	183 (68.5)	183 (55.0)
Minor surgical intervention	30 (11.5)	48 (18.0)	42 (12.6)
Major surgical intervention	25 (9.6)	36 (13.5)	108 (32.4)

is affected by the fall height, the body part hitting the ground, and type of ground where the fall occurred. Any type of trauma has the potential to cause death and disability. Fall from height has a higher likelihood to cause permanent disabilities and a high rate of fatalities compared to other traumas as it is mostly related to SCI. Data from the National Spinal Cord Injury Database (NSCID) show that the percentage of SCI cases caused by falls has increased from 17% in the 1970s to 31% during 2010–2013.¹¹ The National Crime Records Bureau, Ministry of Home Affairs, Government of India, in a published report in 2015 has mentioned that FFH contributed 1.42% of all fatalities due to natural and unnatural causes.¹² These types of injuries have been the subject of much interest as a public health issue in developing countries, due to the disability-adjusted life years (DALYs) associated with it. Occupational risk factors are responsible for 8.8% of the global burden of mortality due to unintentional injuries and 8.1% of DALYs due to this outcome; therefore, this reiterates the need for effective preventive strategies.¹³ This observational cohort study is a multifactorial analysis about the severity of injuries and the associated factors in patients with FFH.

The mean age of this cohort was 36.2 (SD 20.8) years with a male predominance and more than half of the incidents were occupation related. We divided the fall heights into three groups for the purpose of analysis. Based on the fall height, we observed that lower limb injuries were most common in the less than 5 feet height category. In children and elderly, the commonest mode of injury was fall from bed or chair at home. Lower limbs were found to be the most common body part injured followed by spine similar to findings of other studies.¹⁴ A Swedish study on FFH and its long-term outlook demonstrated that these incidents was the predisposing reason in approximately 40% of events that led to the elderly being moved to an assisted living facility.¹⁵ It was noted in our study that with increase in height there was a proportional increase in SCI and decrease in lower limb injuries. In the fall height between 5 feet and 10 feet height categories, majority were upper limb injuries secondary to domestic injuries, fall from stairs or ladders, or were occupational related. Victims with history of fall from 10 feet or above were more hemodynamically unstable in comparison to the other group. The most common mode of injury was fall from tree and workplace related. Higher rates of SCI, calcaneal, and pelvic fractures were observed in this group. Most of these workers had the protection of a helmet but additional safety equipment should be used based on height to protect other regions of the body also. The severity and extent of SCI defined according to the ASIA scale was directly proportional to fall height. It was noted that with increase in the fall height the NISS also increased, implying that severity of injuries is directly proportional to the fall height. Our results were similar from a study done in the West, where SCI was predominantly seen in the more than or equal to 10 feet height category.^{15,16} Therefore, it is always wise to assume that any patient with FFH has a SCI. Majority of the patients were stabilized and could

be discharged directly from the ED after primary care. This was also possible due to qualified and efficient ED professionals, aided by the backbone of a multispecialty team of trauma surgeons, spine surgeons, neurosurgeons, orthopedic surgeons, plastic surgeons, and ENT surgeons.

Although majority of the study population was discharged in a hemodynamically stable condition, the ones who sustained SCI with neurological impairment are likely to have long-term morbidity.

Strengths

The strength of our study is a large sample size ($n = 861$), the use of physiological scoring of severity (triage priority), and anatomical scoring of severity (NISS). Bivariate and multivariate logistic regression analysis for factors associated with fall height is another strength of our study.

Limitations

These are data from a single large tertiary care center, which results in patient selection and an inherent referral pattern bias. The fall height was inferred from the patients or relatives; hence, there is chance of recall bias. Missing patient records and incomplete data were other limitations of our retrospective study.

CONCLUSION

Fall from height is one of the leading causes of morbidity and mortality among trauma patients. We observed that young adult men were the usual victims. The most common mode of injury was fall from bed or chair at home and was mostly seen in children and elderly. It was noted that with increase in fall height there was a proportional increase in SCI and decrease in lower limb injuries and therefore it is always wise to assume that any patient with FFH has a SCI. Injury prevention measures must be taken to prevent and reduce risk of FFH in various sectors, in both urban and rural areas.

RESEARCH QUALITY AND ETHICS STATEMENT

The authors of this manuscript declare that this scientific work complies with reporting quality, formatting, and reproducibility guidelines set forth by the EQUATOR Network. The authors also attest that this clinical investigation was determined to require institutional review board/ethics committee review, and the corresponding protocol/approval number is IRB Min no: 12222 dated August 22, 2019. We also certify that we have not plagiarized the contents in this submission and have done a plagiarism check.

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