

Fatalities Following Fall from Heights Presented to Three Medico-Legal Units in Sri Lanka

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Abstract

Introduction: Fall from heights is a common form of unintentional injury. The objective of this study is to determine the pattern of injuries, risk factors, and safety measures employed in relation to such falls.

Methods: Data was collected from cases of fatal falls presented to the medico-legal units at Kandy, Peradeniya, and Panadura in Sri Lanka from 2005 to 2016.

Results: In the sample considered the majority were males (93%) between 41-60 years (49%). Most were accidental (88%) and 41% sustained injuries by falls from trees. The commonest region of injury was the head and neck (71%) with the site of primary impact being the same. The most common injuries in the head, thorax, and abdomen/pelvis were skull fractures (60%), rib fractures (84%), and liver lacerations (59%), respectively. The main skull fracture was linear (67%), with the commonest site being the temporal (36%) and occipital (36%). With increasing height, the frequency of injuries to the thorax, abdomen, pelvis, and limbs also increased. Most (68%) died after being brought to hospital. Alcohol consumption was estimated as 10% in the sample considered.

Conclusion: None had been using any safety equipment. This study underscores the importance of protective devices for people who work at heights to prevent fatalities. Compliance can be further enhanced by creating awareness among the vulnerable groups.

Keywords: Fall from heights; injuries; mortality; protective devices; risk factors

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Introduction

One of the most common modes of sustaining unintentional trauma in the Western world is falls, which is only second to road traffic accidents.[1] The term 'falls' encompass those occurring under many different circumstances including falls from stairs/steps, ladders, buildings, into holes, from one level to another (e.g.: from playground equipment), from cliffs or furniture, and falls on level ground as a result of slipping, tripping, or stumbling or in sports.[2-6] Deaths following history of a 'falls' are routinely encountered by the forensic pathologist

during death investigation including autopsy examination. However, cases of vertical fall from heights or vertical deceleration is an entity which is not an unusual forensic presentation with paucity of research in this area.[7] Many such studies had not clearly analysed the mechanism and pattern of trauma.[8]

The Epidemiology Unit of Sri Lanka states that the falls comprise 03% of all unintentional injuries.[9] Most studies related to such injuries have only addressed either the pattern of injuries or isolated

demographic aspects. Therefore, a complete and representative picture of fatalities due to falls from heights is still lacking. This study was conducted with the intention of broadening the current medical knowledge on fatalities due to falls from heights in order to reduce the incidence and develop better safety protocols.

The objectives of this study were to determine with regard to those who succumb to falls from heights, the pattern of injuries, safety measures adopted at-risk groups and the usage of alcohol.

Methodology

In this retrospective study, the data collection tool used in the study was a questionnaire designed to evaluate the demographic parameters, contributory factors, and associated injury patterns of all fatalities in falls from height. Data regarding fatalities due to falls from height were accessed from police reports, eyewitness accounts, bed head tickets (BHTs), and post-mortem reports from three medico-legal units at Kandy, Peradeniya, and Panadura in Sri Lanka from 2005 to 2016. Data was obtained by liaising with specialists in forensic medicine who were in charge of each unit. Only the vertical falls more than a height of two meters was considered. The exclusion criteria were victims aged less than 14 years, lack of evidence or credible details on the method and parameters of the fall, disease or physical condition or any factors influencing the fall, natural diseases directly or indirectly contributing to the cause of death, rolling-over injuries, putrefied bodies and cases where the manner of death was suspicious. Data was entered into and analyzed using Microsoft Excel and IBM SPSS Statistics version 22.0, respectively. Data analysis was conducted to determine the pattern of injuries sustained by the fall, safety measures adopted, at-risk groups and the usage of alcohol. Ethical approval (2016/EC/40) for this study was obtained from the Ethics Review Committee of Faculty of Medicine, University of Peradeniya, Peradeniya, Sri Lanka.

Results

Out of 26,920 medico-legal post-mortems performed from 2005 to 2016, 877 cases had a history of fall and 124 fatalities were selected considering the inclusion and exclusion criteria. The youngest victim identified in our study was 16 years old while the eldest individual was 83 years.

Socio-demographic profile

Ninety three per cent were males with 49% being 41-60 years of age, 20% being 21-40 years and 19% being 61-80 years of age. Falls were relatively rare in those less than 20 years (06%) and more than 81

years (05%). Of the deaths, 88% were accidental, 02% were suicidal and 10% were undetermined in nature. The majority were employed as unskilled labourers (38%) at the time of the fatal accident.

Analysis of the location from which they fell revealed that 41% fell from tall trees, 16% fell from buildings, 10% from a hill, 06% down a staircase, 03% from a tall parked vehicle (roof of shipping container truck/tipper lorry/boom truck). A significant proportion (24%) fell from ladders/lamp posts or tables.

Analysis of patterns of injuries

Height of fall

The distribution of falls from height and the region of the injury are shown in Tables 1 and 2. The majority had fallen from a height of 6-20 feet followed by 21-40 feet (Table 1).

Table 1: Distribution of fatal falls by height

Height of fall in feet (meters)	Frequency N=124 n (%)
06-20 (02-06 m)	71 (57)
21-40 (07-12 m)	31 (25)
41-60 (13-18 m)	14 (11)
61-80 (19-24 m)	01 (01)
81-100 (25-30 m)	02 (02)
101-120 (31-36 m)	01 (01)
121-140 (37-43 m)	01 (01)
>140 (>43 m)	03 (02)

Table 2. Distribution of fatal falls by the region of the injury.

Region involved	Frequency N=182 n (%)
Head & neck	94 (52)
Thorax	60 (33)
Abdomen/pelvis	19 (10)
Limbs	09 (05)

Probable primary site of impact

This study revealed that the sites of primary impact were the head and neck (71%), chest (18%), abdomen (02%), and limbs (01%) with the site unknown in 08% of cases.

Injuries to the head and neck

Evaluation of injuries to the head and neck region revealed that a majority of victims sustained a combination of injuries. Of all those who sustained head and neck trauma, skull fractures were the commonest (60%), followed by 51% intra-cerebral haemorrhages, 46% cortical injuries (both

lacerations and contusions), 11% brain stem injuries and 06% cervical spine injuries.

The commonest type of skull fracture was linear and placed on the vault (67%). Depressed, basal, comminuted, and hinge fractures represented 28%, 33%, 19%, and 09% respectively. The temporal (36%) and occipital (36%) were the most frequently involved bones of the skull. The parietal and frontal bones were involved in 24% and 14% of cases respectively while the facial bones were involved only in 04% of cases.

Injuries to the thorax

The most common thoracic injuries were rib fractures (84%), haemothorax (45%), lung contusions/lacerations (18%), clavicle fractures (09%) and sternal fractures (07%).

Injuries to the abdomen and pelvis

The most common injury to the abdomen/pelvic region was liver lacerations (59%), lumbar/pelvic fractures (41%), splenic lacerations (24%), and laceration and perforations of gastro-intestinal system (12%).

Injuries to the limbs

A large contusion was seen on the knee joint with femur fracture in one of the cases while 02% sustained fractures of forearm bones, 04% showed extensive lacerations and 77% demonstrated abrasions, small contusions, and superficial lacerations.

Injured regions with height of fall

With increasing height, there was a gradual increase in the proportionate involvement of the thorax, abdomen/pelvis, and limbs

Period of survival after fall

The majority of the victims (68%) had died after being brought to the hospital, 19% died on the way to the hospital, 13% were found dead at the scene. Of all deaths that occurred after admission, 43% died in the first 6 hours, 14% died between 6-12 hours, 06% died between 12-24 hours and 05% died after 24 hours.

Analysis of risk factors

There were a number of risk factors for fall from heights. However, the usage of safety measures and consumption of alcohol/substance were specially considered and analysed in our sample. The most significant finding during the analysis was the failure of all of the victims to use any sort of safety equipment which led to fatal outcomes following falls. None had used even primary methods of safety

such as a rope, harness or any safety devices, such as protective headgear, specialized clothing or footwear. The data which was obtained from the attending first contact Medical Officer's notes as well as the laboratory evidence of alcohol levels in blood obtained at autopsy revealed that 10% had consumed alcohol.

Discussion

The International Classification of Disease (ICD 9) states that 'a fall from height is an unexpected event where a person falls to the ground from an upper level.[10] It is also defined as 'a descent from upright, sitting or horizontal position, the decent height being less than or equal to 1 meter.[11] The Frailty and Injuries: Co-operative Studies of Intervention Techniques (FICSIT) studies defines a fall as 'unintentionally coming to rest on the ground, floor or other lower level'.[12] Even small variations in the definition of falls can alter the conclusion of a study on fall from height.[13] Falls can be categorised based on the reason for the fall: intrinsic (internal factors contributing to the control of posture of the body) or extrinsic (external environmental factors).[13]. Depending on the height of the fall, it can be divided into low falls and high falls.[14]

A cross-sectional study conducted in Sierra Leone identifying causes of traumatic injuries in developing countries revealed that 'falls were the most common cause of non-fatal injuries, accounting for over 40% of injuries.[15] The principal factors which determine the nature of injury in falls from a height are 'the height of fall, body weight, velocity, nature of surface impacted, orientation of body at the moment of impact and the elasticity and viscosity of tissues of the contact body region, out of which height of fall is the major determining factor'.[16] Thus, determining the nature of the injuries sustained may aid in hypothesizing the height, angle, and position of the victim, in cases where information about the circumstances and cause of death may be lacking.

Sri Lanka is a lower middle-income country[17] and 35% of the workforce is employed in the agriculture sector which involves more than 40% of the total land area.[18] When analysing the occupation against gender in Sri Lanka, no significant gender discrimination prevailed.[19] The cultural and social background of Sri Lanka encourages males to engage in occupations which involve heights, including tree climbing and building construction. This might be the reason for the male predominance in our study and the most common method of fall being trees. The produce from trees such as coconut (Cocos nucifera), jackfruit (Artocarpus

heterophyllus), durian (*Durio zibethinus*), clove (*Syzygium aromaticum*), avocado (*Persea americana*), mango (*Mangifera indica*), and rambutan (*Nephelium lappaceum*) contributes significantly to the economy of the country as well as to domestic consumption. These are manually plucked by male labourers, after climbing the trees of approximately 10-60 feet in height. Also, Sri Lanka has a number of tropical forests.[20,21] Many domestic needs are met by felling trees for firewood, furniture and construction and tree climbers play an important role. However, there is a significant shortage of such workers due to lower salaries, higher literacy, inability to climb trees in monsoonal periods, poor job recognition, fatal outcome or permanent disability following falls, and absence of insurance or compensation when injured. However, many tree climbers engage in this occupation on part-time basis.

A study conducted in 1993, on the correlation between age and fatalities due to occupational falls, revealed that the number of fatalities increased from age group 45-54 years.[22] Furthermore, the study revealed that low-energy impacts had a higher chance of fatality in older people compared to younger age groups.[22] Our study revealed that those between 41-60 years of age represented almost half of all fatalities. Furthermore, a significant proportion (20%) was of the 21–40-year age group, which was similar to previous studies. [23,24] In the present study, the majority (38%) were unskilled labourers who worked as part-time tree climbers, as a means of additional income. This may be speculated as a cause of fatal falls from trees. The vast majority (93%) of falls had occurred from heights of less than 60 feet, with a significantly high percentage (57%) having sustained falls from heights less than 20 feet. This may be explained by the fact that the most common type of falls was falls from trees, whose heights are usually within that range.

The head and neck were the commonest primary site of impact (71%) and the region involved (75%) followed by chest and abdomen which are compatible with findings of similar studies. [25-29] One reason for the high numbers of head injuries may be the lack of usage of safety measures like helmets, safety lines, harnesses etc. especially among the tree climbers in Sri Lanka. However, literature revealed that thoracic injuries were seen in 98% of the study population followed by injuries to head and face (82%), internal organs of abdomen and pelvis (79%) and pelvic girdle (55%).[7] In our study, it is a limitation that only fatalities are considered and hence cannot come to a generalized

conclusion that the falls cause head injuries commonly.

The primary site of impact is where the area of the body which first impacts the ground and it is very important to reconstruct the event. However, the primary site of impact is difficult to determine and may only be an opinion after evaluating all injuries, an 'educated guess'. [8] However if there is overwhelmingly predominant head injuries, it is indicative of a primary head impact.[20] In this study the possible site of primary impact as the head and neck was determined after evaluating injuries of the deceased, findings at the scene of fall and eye witness accounts. Another study revealed that the head and face were the commonest areas of primary impact (47%) followed by a side of the body (37%), feet and lower limbs.[30] Commonest injuries seen in the head and neck area, according to descending frequency, were fractures of the skull and cervical spine, intra-cerebral haemorrhages and cortical injuries which were compatible with previous studies.[8]

When considering types of skull fractures, linear type was the commonest followed by depressed, basal and comminuted fractures, respectively. According to a study conducted in India in 2012, linear fracture was the commonest skull fracture recorded in 26% of cases, with comminuted fracture recorded in 23% of cases.[14] This study identified the temporal and occipital bones as the most commonly involved bones associated with skull fractures almost equally representing 72% of all subjects those with skull fractures. According to a similar study from Bangladesh, conducted in 2015, the commonest skull fracture type was linear (51%) followed by comminuted and ring fractures, while the regions involved were temporal, followed parietal and frontal in descending order.

Fractures of sternum and ribs, lung contusions and liver lacerations suggest an anterior impact, frontal falls or by impact/primary contact with the horizontal branches of the trees whilst falling before landing on the ground. Furthermore, fractures of lumbar vertebrae/pelvis were significantly higher than the limb injuries, which indicate that most victims landed either on the buttocks or lower back and had been unable to break the fall by using the limbs. In our sample, 88% died due in an accidental manner and it was similar to a study conducted in India,[30] but many studies showed suicides contributed to more than the accidental deaths [32-35].

Furthermore, it is possible that most victims of our study fell from 6-20 feet and sustained fatal injuries to the head region. Cummins et al. who conducted a study of head injuries following falls above 10 feet concluded that the velocity of the impact was not significantly associated with skull fractures accounting for 42% of all head injuries.[36]

The injuries to the cervical spine were predominantly seen in our study and it is also seen in other studies as well.[7] However, literature revealed that spinal injuries were seen more in the thoracic region.[20,25,37,38]

The definition of 'jumpers' and 'fallers' have been explained to those individual sustaining intentional and accidental free falls, respectively.[35] In our study, almost all victims died in an accidental manner which may be a reason for less injuries on lower limbs.[39- 41]

In most Sri Lankan localities, the trees are less than 60 feet tall. The stout branches and the undergrowth of many smaller trees around the large trees limit the visibility of the ground. This may prevent the victim from reacting in a protective way by breaking the fall.

Out of the thoracic injuries, the commonest were rib fractures, haemothorax, and lung contusions. This was similar to a post-mortem study conducted by Gupta who identified lung injury due to fractured ribs and compression in 85% and haemothorax in 31%[42] and other studies too supported this finding.[29,43]

The liver is the most commonly injured organ in fatalities due to abdominal injuries in free fall[35] which was similar to the observations made by above study.[42] In our analysis the commonest injury of the abdomen and pelvis were liver lacerations, constituting 59% of all injuries of that area. Splenic injury also represented a significant component in our sample which is similar to previous records.[20,42] Furthermore it was evident that the liver and splenic injuries were common even in falls from less than 40 feet because the majority of our sample fall from trees and probably impacted on intervening objects such as tree branches before landing on the ground. Another possibility is resuscitation which is known to cause injuries to the liver, spleen, sternum etc.[44,45] However this was excluded at autopsy examination by the absence of overlying skin injuries, pattern of injuries and hospital notes.

Injury pattern depends on many factors such as body weight, height of fall, body dynamics while falling, age, landing surface etc.[24,35,46-50] This study revealed that with increasing height of fall, there was an upward tendency of causing injuries to thorax, abdomen/pelvis, and limbs respectively. There is also a predominance of multiple injuries with increasing in the height of fall which was also seen in other studies.[20]

The majority of the victims (68%) died after being admitted to the hospital. This was probably due to the fact that the falls in our study occurred from lesser heights. Evidence of alcohol consumption was noticed in a significant proportion of victims (10%) at the first encounter with the medical personnel and during autopsy by the forensic pathologist. Alcohol consumption is a known risk factor in falls from heights.[16,30,51,52] which is also seen in our study. Regrettably, the exact amount of blood alcohol levels of the individuals could not be determined due to the lack of available data on admission. Since most of the victims died after hospital admission, most had undergone extensive resuscitation procedures (e.g. massive crystalloid and colloid infusions), thereby rendering the testing of post-resuscitation blood alcohol levels, futile.

Furthermore, several other key factors were uncovered during the course of this study. Out of the 124 cases which were considered in our study, none had been using any safety gear at the time of fall, regardless of their occupation and site of fall. Additionally, none had complied with any safety standards despite being required to wear safety gear at all times whilst working at heights. Protective equipment including head gear, harnesses, boots and safety lines are likely to protect the vital areas and lessen the severity and frequency of falls. Disregarding the use of safety measures may have been a key factor for fatalities in these individuals.

On the other hand, tree climbers or personnel working at heights in Sri Lanka do not undergo training nor are they assessed for fitness. The term 'Qualified Tree Climber' is defined as a worker who, through related training and with the experience, shows familiarity with the techniques and hazards involved in tree maintenance and removal, and uses special equipment.[53] It is time to think of reformulating and implementing guidelines for this vulnerable group. Public education and awareness among the general population, on safety methods to be used when working at heights, have to be ensured to reduce injuries sustained due to falls.

Conclusions

This study revealed that, in the given sample taken from three medico-legal units, a majority of victims were middle-aged males who fell from trees accidentally. The most vulnerable regions were the head and neck with the primary site of impact presumed to be the same in such fatal falls. None had been using any safety equipment at the time of the fall. There was evidence of a significant proportion of victims having consumed alcohol prior to the event. Regulations must be enforced to ensure that those working at heights comply with the necessary safety standards. Compliance may be further enhanced by creating awareness among the vulnerable groups.

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