

# Injuries sustained by falls

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## SUMMARY

During a recent 4-year period, 381 patients were admitted with injuries sustained from falls. Equal numbers of patients were less than and greater than 50 years of age and included 53 children ( $\leq 16$  years) and 214 elderly ( $\geq 55$  years). Falls from heights occurred predominately in young males (mean age 34.2 years), were most commonly job or recreation related and resulted in higher injury severity scores (ISS). Falls in the elderly occurred more commonly in women, typically on a flat surface, and were less severe. Despite lower mean ISS, fall victims over 55 years of age had longer hospitalizations (11.4 *vs.* 4.5 days) and incurred higher hospital charges compared to younger patients. There were 35 deaths (9.2%). In patients under 55 years, deaths resulted from fall-related central nervous system (CNS) injury and/or multisystem trauma. In patients over 55 years, fatalities were most commonly related to pre-existent medical conditions.

Based on a review of this experience, we conclude that:

- (1) unlike other causes of blunt and penetrating trauma, both sexes are equally at risk from fall-related injuries but sex incidence is age related;
- (2) falls from heights are more common in men;
- (3) advanced age and pre-existing medical conditions account for the increased morbidity and mortality following falls and;
- (4) cost containment measures for fall-related trauma must consider not only injury severity, but the age and pre-existent medical conditions of the patient.

## INTRODUCTION

Falls are the second leading cause of both spinal cord and brain injury (accounting for 20% of CNS trauma in the United States) and constitute a major cause of trauma deaths in all ages (Maull *et al.*, 1981; Barancik *et al.*, 1983). In addition, falls are the most common cause of non fatal injury. Each year one person in 20 is injured

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seriously enough from a fall to require emergency department evaluation and treatment. If hospitalization is required, the patient may have multisystem trauma or severe isolated musculoskeletal or CNS injuries, all of which may be life-threatening or lead to physical impairment and lasting disability. An increasing awareness of this problem in our own trauma patient population promoted this review.

## METHODS

The University of Tennessee Medical Center, a verified Level 1 trauma centre received 381 patients injured by falls during the 4-year period ending December 1987. Thirty-five patients were dead on arrival or expired shortly thereafter in the emergency department and were classified as 'early deaths' (Group 1). Each patient in Group 1 was a medical examiner's case and information was obtained from the medical examiner's records and/or post-mortem examination. Group 2 consisted of 346 patients injured seriously enough to require hospitalization. Medical records were reviewed and age, sex, circumstances of fall, site of incident, injuries sustained, and outcome were determined for each patient. Length of hospital stay (LOS) was defined and pre-existent medical conditions were carefully sought. Falls were classified as accidental or intentional and the incident site identified as 'workplace', 'recreational', 'home', or 'other'. A significant number of patients in the latter category involved moving vehicles.

## RESULTS

There were 35 patients in Group 1, 30 men and 5 women, ranging in age from 11–75 years with a mean age of 35.4 years. Ninety-four per cent of the deaths (33 patients) were classified as accidental while the remaining patients (6%) successfully committed suicide. Recreational injuries and falls from moving vehicles were the most common causes of fatal falls (Table 1). Head injury was the leading cause of death (15 patients) followed by multisystem trauma.

**Table 1.** Site of injury occurrence.  
Group 1-DOAs ( $n = 35$ )

Site	Number
Recreational	13 (38%)
Moving vehicles	13 (38%)
Workplace	5 (12%)
Home	2 (6%)
Aircraft	2 (6%)

There were 346 patients in Group 2, 165 males and 181 females. Age ranged from 1 month–96 years with a mean age of 44.2 years. The subgroup aged over 55 was composed of 214 patients of which 165 were women. Mean age was 75 years. In the elderly subgroup, there were 400 risk factors identified. Pre-existing medical conditions were absent in 48 patients aged over 55 (Table 2). Among the 132 patients under 55, there were only 28 women. Mean age in the younger subgroup was 24.5 years. Concurrent disease was absent in 97 of the 132 patients. There were 53 children (< 6 years).

Home mishaps predominated in Group 2 patients but recreational injuries were also common (Table 3). Only 12% occurred at work, and 22 patients in this group (6%) fell from moving vehicles.

**Table 2.** Risk factors in patients\* injured by falls

Risk factor	Age > 55 (n = 214)	Age < 55 (n = 132)
Cardiovascular	179	14
Metabolic	69	7
Respiratory	48	6
CNS	27	12
Psychiatric	26	2
Renal	15	—
Gastrointestinal	8	1
Other	28	9
<b>Total</b>	<b>400</b>	<b>51</b>

\* More than one risk factor per patient

**Table 3.** Site of injury occurrence.  
Group II-patients, (n = 346)

Site	Number
Home	73 (21%)
Recreational	62 (18%)
Moving vehicles	22 (6%)
Truck (10)	
Horse (4)	
Motorcycle (3)	
Golf Cart (2)	
Swing (2)	
Workplace	39 (12%)
Other	5 (1%)
Not stated	145 (42%)

The mechanism of injury in Group 2 patients was most frequently a fall from height (Table 4). It usually occurred in young males (mean age 37.8 years) and most commonly was job or recreation related. Most falls in the elderly occurred in or about the home and on a flat surface. Falling down stairs was the second leading cause of injury in patients older than 55 years.

Table 5 demonstrates the specific injuries encountered in the Group 2 patients and their relative frequency (the total number of injuries exceeds 346 since many patients had more than one injury). As expected, musculoskeletal injuries predominated, especially those involving the lower extremity, which occurred in 77% of patients. Distressingly, head injuries (skull fractures or cerebral contusions) were also common and isolated CNS trauma occurred in 33 of these 79 patients, almost half in children.

Table 6 contains data on ISS, LOS, and hospital charges. Despite a slightly

**Table 4.** Mechanism of injury occurrence, Group II Patients, ( $n = 346$ )

Circumstances	Number
Fell from height	171 (50%)
Roof (7)	
Window (2)	
Ladder (18)	
Tree (13)	
Stairs (31)	
Scaffold (4)	
Other (96)	
Fell on surface	110 (32%)
Home (62)	
Outdoors (48)	
Not stated	65 (18%)

**Table 5.** Injuries sustained by falls, Group II patients ( $n = 346$ )

Injury	Number
Head	79 (23%)
Spine	44 (13%)
Cervical (5)	
Lumbar (39)	
Musculoskeletal	269 (77%)
Upper extremity (86)	
Pelvis (53)	
Lower extremity (130)	
Chest	42 (12%)
Intraabdominal	20 (6%)

**Table 6.** Hospitalization and hospital charges versus ISS and patient age

Criteria	Age > 55	Age < 55
Mean ISS	7.3	8.3
Mean LOS	11.7	4.5
Hospital charges (Av)	\$8424	\$5150

higher severity of injury in the younger subgroup, when compared to patients over 55 years, the mean LOS was significantly greater in the elderly (11.4 days *vs.* 4.5 days). Longer hospital stays were reflected in greater hospital charges in the older patients. In addition, regardless of the severity of injury, the morbidity and mortality encountered were closely related to pre-existent medical conditions as well as age. Of the 16 deaths in Group 2, 14 occurred in the elderly group, (mean age of 78.6 years), and pre-existent cardiorespiratory disease was the most common cause of death. Two patients died as a direct result of a fall-related CNS injury.

## DISCUSSION

Falls account for more than 16000 deaths each year in the United States and represent the leading cause of unintentional injury reported by hospital emergency departments. (Maull *et al.*, 1981; Barancik *et al.*, 1983) Baker *et al.* (1984) suggest that this figure underestimates the true incidence of significant falls since an even greater number of patients die under circumstances where a fall only initiates or contributes to the cause of death yet is not reported. Among unintentional injury deaths for all ages falls rank second, behind motor vehicle crashes, which lead all other causes of trauma related fatalities (Nahum & Melvin, 1985). In children falls rank fourth in traumatic causes of death, behind motor vehicle crashes, fires and drowning (National Safety Council, 1983). A 1978 study of 345 fatalities due to falls or jumps from noncrash motor vehicle incidents showed that 44% of the patients were under 5 years old (Williams & Goins, 1981). Although the relative lethality of falls, i.e. death per incident, is significantly less than for vehicular trauma, the magnitude of the problem of all-related trauma remains a major health concern.

The kinematics of motor vehicle crashes and falls are not dissimilar – both are deceleration-type injuries. Whenever an external force is applied to the human body, the severity of injury is the result of the interaction between the physical factors of the force and the body. If the body is in motion, i.e. falling, and impacts a fixed surface, the extent of the injury is related to the ability of the stationary object to arrest the forward motion of the body. At impact, differential motion of tissues within the organism cause tissue disruption. Decreasing the rate of the deceleration and enlarging the surface area to which the energy is dissipated increases the tolerance to deceleration by promoting a more uniform motion of the

tissues. The fall arresting contact surface is also important since concrete, asphalt, or hard firm surfaces increase the rate of deceleration ( $\Delta V$ ), and are associated with more severe injuries (Cummins & Potter, 1970; Reichelderfer *et al.*, 1979; Garrettson & Gallagher, 1985). Cummins & Potter emphasized the importance of contact surface and suggested that this is more important than the height of the fall. They showed that victims striking hard ground or concrete suffered greater injury than those who hit grass, even though the distances were similar.

Certain features of living tissue must also be considered, especially the combined cohesive properties of elasticity and viscosity of tissues. The tendency for a tissue following impact to resume its prestressed condition is related to its elasticity. Viscosity implies a resistance to change of shape with changes in motion. The tolerance of the organism to deceleration forces is a function of these combined cohesive properties and the point beyond which additional force overcomes this tissue cohesion determines the magnitude of the injury (Maull *et al.*, 1981).

There appears to be little doubt that the severity of injury is closely related to the kinematics of vertical deceleration, the combined cohesiveness of the body's properties, and the consistency of the impact surface. Yet the resultant morbidity and mortality do not necessarily coincide. Historically age is the most consistent variable defining differences in fall morbidity and mortality rates, with the highest incidence occurring in early childhood and the elderly (Galasko & Edwards, 1974–75; Gallagher *et al.*, 1984; Garrettson & Gallagher, 1985). This experience with fall-related trauma confirms that there are certain epidemiologic factors specifically related to the age of the patient that contribute to morbidity and mortality. These observations are particularly pertinent in today's climate of cost containment.

Our experience demonstrates that, unlike other causes of blunt and penetrating trauma, both sexes are at relatively equal risk from fall-related injuries. However, greater sex variation is noted when the age and circumstances of the fall are carefully considered. Falls during recreational activities, in job-related circumstances, and in the young are much more common in males. This is counterbalanced in later years by a higher population of female patients who fall, particularly on level surfaces. Baker *et al.* (1984) attribute the high death rate in the elderly to be secondary to their greater likelihood of pre-existent medical conditions such as impaired vision, gait disturbance, lack of balance, bone weakness from osteoporosis, and a greater susceptibility to complications. Our findings support their observation since 14 of the 16 deaths in Group 2 were in elderly patients and related to pre-existent cardio-respiratory diseases.

Most falls in the elderly and the very young occur in or near the home. Prevention programmes are unlikely to have a meaningful impact on this segment of fall-related injuries. Yet both groups have potentially preventable injuries. The cost of observing building codes which make safer stairways, windows, and handrailings would almost certainly be recaptured by savings in trauma care costs. Falls in nursing homes alone account for over 1800 deaths annually (Baker *et al.*, 1984). In this report, 34 patients sustained injury after falling from moving vehicles, and 13 patients died (38% mortality). Closer supervision and use of seat belts and child restraint devices may greatly impact this segment of the problem.

Determinants of outcome following injury include both controllable factors,

such as quality of care rendered and time from injury to definitive care, and certain uncontrollable factors, among which injury severity is considered both the most important and most preventable. However, the age of the patient and pre-existent medical conditions (risk factors) are also determinants of trauma outcome over which there is little or no control. In 1974, Baker *et al.* confirmed that survival following injuries of equal severity was lower for patients aged over 55 compared to those under 55 (Baker *et al.*, 1974). Our data supports the validity of patient age as a trauma outcome determinant, and further correlates advanced age and risk factors with length of hospitalization and health care costs.

In summary, deaths from accidental falls are far more common than from intentional falls and both sexes are equally at risk. Falls during recreational and job-related circumstances, from heights and in the very young are more common in males. Falls occurring at home are more common in women. Unquestionably, advanced age and pre-existent medical conditions contribute significantly to the increased morbidity and mortality following falls. This is an important fact that society must address, to provide adequate hospital reimbursement for LOS following such injuries in the elderly. Potentially preventable fall-related injuries were noted in nursing home residents and children. As is true for most causes of trauma, prevention of fall injuries has considerable potential for cost savings and the lessening of morbidity and mortality.

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