Non-Hip Fracture-Associated Trauma in the Elderly Population

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Abstract

Background: The rate of trauma in the elderly is growing.

Objectives: To evaluate the characteristics of non-hip fracture-associated trauma in elderly patients at a level I trauma center.

Methods: The study database of this retrospective cohort study was the trauma registry of a level I trauma center. Trauma patients admitted from January 2001 to December 2003 were stratified into different age groups. Patients with the diagnosis of hip fracture were excluded.

Results: The study group comprised 7629 patients. The non-hip fracture elderly group consisted of 1067 patients, 63.3% women and 36.7% men. The predominant mechanism of injury was falls (70.5%) and most of the injuries were blunt (94.1%). Injury Severity Score was found to increase significantly with age. The average mortality rate among the elderly was 6.1%. Age, ISS, Glasgow Coma Score on admission, and systolic blood pressure on admission were found to be independent predictors of mortality.

Conclusions: Falls remain the predominant cause of injury in the elderly. Since risk factors for mortality can be identified, an effective community prevention program can help combat the future expected increase in morbidity and mortality associated with trauma in the elderly.

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The elderly (65 years of age and older) constitute only 7% of the world's population, but 12% of western countries' total population [1]. This population is projected to grow considerably in both absolute and relative terms. It is estimated that by the year 2030, 20% of the United States population will be older than 65 and 2.5% older than 85 [1]. The rate of trauma in the elderly population is growing. An overall increase of 17% in the number of traumatic injuries in the 75–84 year old age group between 1994 and 1998 was demonstrated in the New Yorks State Trauma Registry [1].

Several studies in recent years have investigated the characteristics of traumatic injuries in the elderly [2-4]. Most of these studies are large trauma registry databases, comprised of heterogeneous trauma mechanisms and pathologies. Patients with isolated hip fractures, who represent at least 21% of the admissions incorporated into the trauma registry, were considered to be a unique group. They differ from other trauma patients in their higher rates of mortality, hospital stay and complications [5]. Although the tracking of such a group is important for the evaluation of the entire trauma population, it is only logical to exclude isolated hip fractures from other traumatic injuries when evaluating the data on elderly patients.

The objectives of this study were: a) to identify the characteristics of non-hip fracture elderly trauma patients and to compare these characteristics with those of other younger trauma patients; b) to report the distribution of causes of injury for different age groups among the elderly; and c) to identify the significant predictive factors for mortality and their relative importance for non-hip fracture elderly trauma patients.

Patients and Methods

This retrospective cohort study reviewed data from the Israel National Trauma Registry of a level I trauma center. All patients hospitalized with trauma in the Tel Aviv Sourasky Medical Center from 1 January 2001 to 31 December 2003 were included in the cohort. Patients with the diagnosis of isolated hip fracture were identified and then excluded from the study. The remaining patients were divided into two major age groups: above and below the age of 65. Patients over 65 were further stratified into another three age subgroups according to age (65–74, 75–84, and 85+ years). Data for each patient included demographic details, information on the injury (diagnosis and circumstances), hospital resource utilization, length of stay, and disposition.

The framework for injury diagnoses analysis was based on the Barell body region by nature of injury diagnosis matrix [6]. The matrix was modified to include five injury types: fractures, internal injuries, open wounds, burns, and others. This matrix describes nine body regions as follows: traumatic brain injury; other head; spinal cord and column; chest; abdomen; pelvis, trunk, back, and buttock; upper extremities; lower extremities; and other. Chest injuries were grouped according to ICD-9-CM codes 807.0-807.4.

SAS statistical software was used for data analysis and for comparison between groups. Statistical analysis included non-

ISS = Injury Severity Score

parametric tests such as Wilcoxon and chi-square tests for comparing between groups of categorical data. Student's *t*-test was used for comparing continuous variables such as LOS, intensive care unit stay, and age. A logistic regression analysis was performed to evaluate the effect of age on mortality when adjusted for gender, Glasgow Coma Score in the emergency department, systolic blood pressure in the emergency department, ISS, and injury circumstances. $P < 0.05$ was considered statistically significant.

Results

During the study period there were 7629 trauma admissions, 2370 of which were patients over 65 years old. Of these elderly patients 3303 (56%) had an isolated hip fracture and were excluded. Patients with isolated hip fracture were older – mean 82.0 years (SD ± 7.3) versus mean 77.6 years (SD ± 7.9) (Wilcoxon $P < 0.0001$), and were more often female (70.5% vs. 63.3%, $P = 0.0002$). These patients had significantly lower ICU admission rates (1.1% vs. 11.4%, $P < 0.0001$) and lower mortality rates (4.1 vs. 6.1%, $P = 0.05$), compared to the study group. Isolated hip fracture patients also had a longer LOS compared to the non-hip fracture group – only 10.7% with LOS of less than 7 days vs. 64.8% in the non-hip fracture group ($P < 0.0001$). The final non-hip fracture-associated elderly trauma group consisted of 1067 patients: 675 women (63.3%) and 392 men (36.7%). The largest group of men was the 65–74 year old group (42.9%), while the largest group of women was the 75–84 year old group (43.7%) ($P = 0.04$). The predominant cause of injury in the elderly was falls (n=752, 70.5%). Higher age groups were associated with higher rates of injuries related to falls: 258 (63.7%) aged 65–74, 309 (69%) aged 75–84, and 185 (86.5%) in the 85+ age group ($P < 0.0001$). The other mechanisms of injury were road traffic accidents (n=239, 22.4%), intentional injury (n=31, 2.9%), other non-intentional injury (n=30, 2.8%) and burns (n=14, 1.3%). Most of the injuries were blunt (n=1022, 94.1%), and the remainder penetrating (n=30, 2.8%) and burns (n=15, 1.4%).

Lower extremity injuries were the most common (n=392, 36.7%), and in these patients 81% (n=318) had no other injury. Upper extremity injury comprised 25% (n=267) of the injuries and was the only injury in 59% (n=157) of those with upper extremity injuries. Traumatic brain injury occurred in 233 patients (21.8%) and this was an isolated injury in 119 (51%). Chest injury occurred in 174 patients (16.3%) and this was an isolated injury in 105 (60%); 125 (72%) of the chest-injured patients had at least one rib fracture, 3 had flail chest, and 12 had a sternal fracture. Eleven of the 140 patients with skeletal injury of the chest died before hospital discharge. The remaining patients had pelvic fractures (n=71, 6.7%), spine fractures (n=58, 5.4%) and abdominal injury (n=22, 2.1%). Traumatic brain injury rates were higher in the old age group (17% for 65–74 vs. 27.1% for those 85 and over, $P < 0.003$). Rates of pelvis/trunk/back and buttock injuries in the older age group were 9.4% at the age of 85+ compared to 5.7% in those aged 65–74 ($P = 0.09$). Surprisingly, upper extremity injuries were less common in the older age group. Upper extremity injuries decreased from 28.4% among the age group 65–74 to 18.7% among those 85 or older ($P = 0.008$), while lower limb injury rates were 43.2% and 30.8%, respectively ($P = 0.003$).

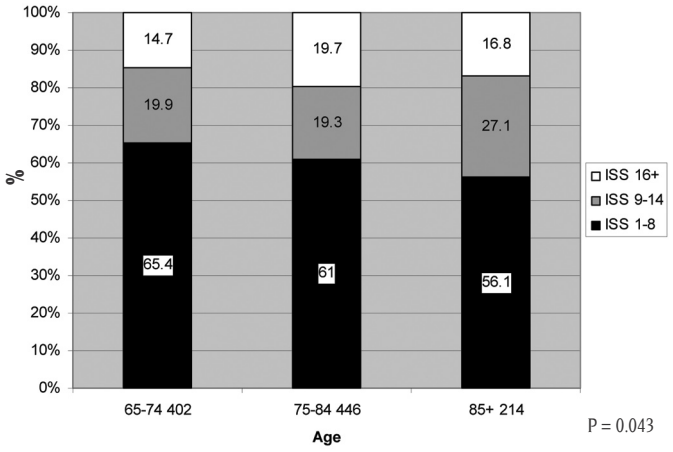

Figure 1. Distribution of ISS according to age group

ISS was found to increase significantly with increasing age ($P = 0.04$) [Figure 1]. Of the 1067 patients in the study group, 132 (12.4%) had a length of stay greater than 2 weeks. The mean LOS was 7.7 days (SD ± 11.9), median 4 days (IQR 25–75% = 2–9). A total of 122 patients (11.4%) were admitted to the ICU. The average length of stay in the ICU was 9.6 days (SD ± 11.3) and the median ICU stay was 6 days (IQR 25–75% = 2–13). Although the rates of ICU stay were higher in the 85+ age group, no statistically significant difference was demonstrated among the different age groups ($P = 0.48$). Surgery was performed in 367 patients (34.4%). Patients in the 65–74 age group had significantly higher rates of surgical intervention (n=188, 46.4%) compared to those 85 and older (n=47, 22%, $P = 0.0001$).

The inpatient mortality rate among all 1067 patients was 6.1% (n=65). Inpatient mortality was related to increasing age. The mortality rates were 3.7% for age 65–74 (n=15), 6.9% (n=31) for age 75–84, and 8.9% (n=19) in the 85+ age group ($P = 0.02$). A logistic regression analysis was performed to evaluate the effect of age on in-hospital mortality [Table 1] while controlling for gender, GCS on admission, systolic blood pressure on admission, and the cause of injury. We found age and GCS to have a significant influence on in-hospital mortality (*P* value of Hosmer and Lemeshov Goodness fit test = 0.93).

Inpatient mortality rates for patients older than 85 years old were 3.4 times higher than those aged 65–74 ($P = 0.03$). Patients with a low GCS (3–5) had an 83.7 times increased chance of dying compared to those with a GCS of 15. Although the inpatient mortality rate among men was found to be almost double, the difference was not statistically significant ($P = 0.1$). The proportion of deaths among motor vehicle accident victims (10%) was

LOS = length of stay
ICU = intensive care unit

GCS = Glasgow Coma Score

Table 1. The effect of age on mortality (adjusted to blood pressure, GCS, gender and ISS)

Characteristic	N	Mortality (%)	Odds ratio	Confidence interval 95%of OR	*P*
Age group					0.03
65–74	395	3.5	1		
75–84	435	6.9	2.1	0.9–4.8	
85+	211	8.5	3.4	1.4–8.6	
Gender					0.1
Female	663	4.2	1		
Male	378	9.0	1.7	0.9–3.3	
GCS*					< 0.0001
3–5	29	75.9	83.7	31.1–225.2	
6–14	37	32.4	14.6	5.9–36.4	
15	975	2.9	1		
Blood pressure*					0.3
< 100 mm/Hg	24	25	2.3	0.5–10.1	
> 101 mm/Hg	988	5.0	1		
Cause of injury					0.6
Falls	736	4.9	1		
Motor accidents	231	10.0	1.4	0.7–3.0	
Other	73	4.1	1.1	0.3–4.8	
Mortality and age while controlling for ISS					
Age					0.049
65–74	405	3.7	1		
75–84	448	6.9	1.7	0.8–3.4	
85+	214	8.9	2.7	1.2–6.0	
ISS*					< 0.0001
1–8	655	0.6	1		
9–14	224	6.7	11.0	3.6–33.7	
16–24	120	13.3	24.3	7.9–74.2	
25+	63	47.6	151.8	50.1–459.5	

* On admission

higher than among those injured by falls (4.9%) and other causes (4.1%), but the multiple logistic regression was not significant (*P* = 0.6). Another logistic regression was performed to evaluate the relationship between age and mortality while controlling for ISS [Table 1]. Both age and ISS were found to be significant predictors of mortality (*P* value of Hosmer and Lemeshov Goodness of fit test = 0.70). When compared to patients with an ISS < 9, patients with an ISS of 25–75 had a 152 times higher mortality rate, patients with ISS of 16–24 had a 24 times increased mortality rate, and patients with an ISS of 9–14 had an 11 times increased mortality rate (*P* < 0.0001 for all comparisons).

The three different age groups were also characterized by different discharge dispositions. The 65–74 age group reached a home discharge rate of 78%, while the next two age groups (75–84 and 85+) reached lower home discharge rates of 67.2% and 66.8%, respectively (*P* = 0.0031).

Altogether, 5024 were in the 0–64 age group and the remaining 1067 (older than 65) comprised the elderly group. Older patients had a higher ISS; mean 7.95 (SD ± 7.87, range 1–9), median 4

Table 2. Proportion of injuries by anatomic site of injury and age

Injury	All (n=6092)	Age 0–64 (n=5024)	Age 65+ (n=1067)	*P* for comparison of age groups
Lower extremity	33.7%	33.0%	36.7%	0.02
Upper extremity	30.9%	32.2%	25.0%	< 0.0001
Traumatic brain injury	15.7%	14.4%	21.8%	< 0.0001
Other head injury (not brain)	20.4%	21.6%	14.7%	< 0.0001
Chest	13.5%	12.8%	16.3%	0.003
Rib fracture	5.5%	4.2%	11.7%	< 0.0001
Abdomen	6.9%	7.9%	2.1%	< 0.0001
Pelvic injury	6.9%	6.9%	6.7%	0.8
Spine injury	6.2%	6.4%	5.4%	0.23

Multiple injuries in one patient are possible

(IQR 25–75% = 4–9), compared to a mean of 6.82 (SD ± 8.11, range 1–75) and median 4 (IRQ 25–75% = 4–9) in the younger group (0–64 years old) (Wilcoxon test *P* value = 0.0001).

The length of stay was more than 2 weeks in 132 of the elderly patients (12.4%). Their mean LOS was longer at 7.95 days (SD ± 7.72, range 0–247) and median 4 days (IQR 25–75% = 2–9), compared to the 0–64 year old group which had a mean LOS of 4.94 days (SD ± 9, range 0–335) and median 3 days (IQR 25–75% = 1–5) (Wilcoxon test P value = 0.0001). The length of stay in the ICU among the elderly was longer, with a mean of 9.64 (SD ± 11.33, range 1–70) and a median of 6 (IRQ 25–75% = 2–13), compared to the 0–64 age group's mean of 6.65 (SD ± 8.98, range 1–80) and median of 3 (IQR 25–75% = 1–8), respectively (Wilcoxon test *P* value = 0.0001).

The overall inpatient mortality rate for all 6092 patients was 2.4% (n=147). The inpatient mortality rate of patients older than 65 was significantly higher than in the younger patients (6.1% vs.1.6%, *P* < 0.0001).

Males comprised 73.2% of the young group and 36.7% of the elderly group (*P* < 0.0001). Blunt injury was the most common cause of injury in all patients (n=5062, 83.2%), followed by penetrating injury (n=853, 14%) and burns (n=167, 2.8%). The rate of blunt injury was significantly higher among the elderly group compared to the young group (95.8% vs. 80.6%, *P* < 0.0001). Falls were the most common cause in the elderly group compared to the young group (70.5% vs. 38%, *P* < 0.0001).

Of the 819 patients with chest injury, 337 (41.1%) had rib fractures, 7 (0.9%) had flail chest and 60 (7.3%) had a sternal injury, totaling 404 patients. Of these, 22 (5.4%) died before hospital discharge. There were 418 patients (6.9%) with pelvic injuries and 380 (6.2%) with spine injuries, but no statistical difference was found between the two age groups in these injuries [Table 2].

The proportion of women in the 65+ age group who died was higher than in the 0–64 age group (46.2% vs. 23.2%, *P* = 0.003). Among the 147 patients who died during hospitalization, 70% had brain injury (75.4% in the older group and 65.9% in the younger), but this difference between the two age groups in that parameter was not significant (*P* = 0.2). Other injuries including those of the chest and abdomen were significantly higher in the

Table 3. The effect of age, blood pressure, GCS (on admission), and gender on mortality in young vs. older patients

Character	N	Mortality (%)	OR	CI	*P*
Age					< 0.0001
0–64	4849	1.6	1	–	
65+	1041	6	16.4	8.8–30.3	
Gender					0.6
Female	1958	2.4	1		
Male	3932	2.4	1.2	0.7–2.1	
GCS*					0.0001
3–5	199	43.7	200.4	104.7-383.3	
6–14	197	10.7	22.9	11.5–45.6	
15+	5494	0.6	1		
BP* (mm/Hg)					0.0012
< 100	362	6.1	3	1.5–5.9	
> 100	5221	1.5	1		

* On admission

0–64 age group ($P < 0.05$). Logistic regression found age, ISS, GCS and systolic blood pressure to be independent risk factors for in-hospital mortality ($P < 0.05$) [Table 3] (P value of Hosmer and Lemeshov Goodness fit test = 0.4).

Discussion

Increasing age puts trauma patients in a higher risk category [1]. Although trauma deaths are not as prominent a cause of death for the elderly, it is the sixth leading cause of death for Americans aged 65 to 74. Since the elderly population is growing steadily [1] and projected to grow in all terms, it is only natural for a trauma surgeon to be familiar with the special injuries and the prognosis in this particular group of patients. Several studies in recent years have investigated the characteristics of traumatic injuries in the elderly, yet most of them are based on large trauma registry data that contain different traumatic mechanisms and pathologies [7-11]. It was estimated that patients with isolated hip fractures represent 21% of those registry entries. The hip fracture group has been identified by others as a unique group, differing in many ways from other elderly trauma patients [5]. In our study, the hip fracture group comprised 20% of the total admissions, and differed from the other group of patients with regard to age, gender and ISS, which correlate well with other reports [5]. We believe that such an important group should be incorporated into the trauma registry, but must be separated from other trauma patients in order not to bias our evaluation of the data.

There is a well-documented male predominance among victims of blunt and penetrating injury [12]. Our data also demonstrated this predominance in the young age group, where males comprised 73% of the injured. That tendency was not found in the elderly group with a female predominance over the age of 65, especially in the 75–84 age group. Sixty-three percent of the injured in the elderly group were women. Female predominance in trauma of the elderly has been described previously [3]. The gender difference between the two groups might be explained by the difference in the cause of injury. While in the younger ages, the predominant cause of injury is motor vehicle accidents and other penetrating injuries, it is well demonstrated that this is different in the elderly where falls from a low height become the principal cause of trauma. Since the rate of male involvement in both motor accidents and penetrating injuries is higher and these causes are more prevalent among young males, it is self-explanatory why male predominance is abolished in the elderly. Furthermore, the increased life expectancy for women in western countries might add to that explanation [13,14]. Falls were described previously as the principal cause in the elderly and were found to be responsible for 67% of their injuries [1,3].

Exclusion of the hip fracture group in our series did not change the ratio of falls as a cause of injury in the population, and although we found that the higher the age the higher the rate of falls, the average rate remained around 70%. That observation emphasizes the fact that regardless of the site of injury, in the older age groups the cause in most cases is falls. Despite the elimination of the hip fracture group we found lower and upper extremity injures (orthopedic injuries) to be the most common injuries (61%). Older people were also found to have higher rates of head, brain and chest injuries, most of which were attributed to falls.

Sixteen percent of our study population had traumatic brain injury. This finding correlates with the literature where traumatic brain injury is described as a substantial public health problem among older persons. Coronado et al. [15] found an age-adjusted rate of traumatic brain injury of 155.9 per 100,000 population. The rates among persons aged 65 years or older increased with age and were higher for males. Although it was found that most of these injuries were mild (73.4%), they were associated with significantly higher morbidity and mortality rates [15].

Since no change was noted during the last 10 years regarding the predominant cause of injury in the elderly, with or without hip fractures, it may be advisable to consider the establishment of a community prevention program, using behavioral and environmental measures that might significantly lower the incidence of trauma in the elderly. Such a prevention program was described by Grahn Kronhed and co-authors [16] with promising results. Medical prevention of fractures with vitamin D supplementation was also found to be of benefit [17].

Unlike Sterling and team [18] who showed no difference in ISS among different age groups in the elderly, we found a significant correlation between higher ISS and older age groups among the elderly (up to 85 years old and older). This might be explained by the elimination of the isolated hip fracture group that is usually characterized by a constant ISS (usually 9), as demonstrated in our results. Therefore, we believe that ISS in the elderly does correlate with outcome in conjunction with other factors such as co-morbidities, which are often present in the older age groups [19].

The average length of stay for the elderly in our study was 7.7 days, median 4 days. These findings correlate well with other recent studies that showed an average LOS of 11.7 days (SD ± 14.9) for non-hip fracture patients and a median LOS of 7 days (range 1–370) [5]. Although the rates of ICU admissions were higher in the 85+ age group compared to those aged 65–69,

no statistically significant difference was demonstrated between the age groups in our study. Likewise, no such difference was demonstrated regarding ICU stay among the young and the old age groups. We showed that older patients had a longer LOS despite no difference in ICU stay. That might be explained by unevaluated factors such as co-morbidities, higher ISS, the need for placement in rehabilitation centers, or the time for establishing a supportive community environment before discharge. Hannan and team [1] showed that 11–38% of elderly patients (depending on age) will be discharged to a nursing home or other healthcare facility, while only 32–59% will be discharged home. Our data also showed lower discharge rates in the elderly population, which was age-related since those aged 65–74 reached a home discharge rate of 78%, while the next two age groups (75–84 and 85+) reached lower home discharge rates of 67.2% and 66%, respectively ($P = 0.0031$).

The mortality among elderly patients is high. Previous studies have shown that in-hospital mortality rises substantially with increasing age from 5.1% for patients younger than 40 to 15% by the age of 85 [1]. Others [19,20] reported a mortality rate of 9.9% in the very elderly, while in a non-hip fracture group the overall mortality only reached 3.9% in one study and 6.7% in another. Our results showed an overall mortality of 6.1% in the old age groups. Mortality was related to increasing age. Similar to other studies the mortality of the very old (85+) was close to 9%. Apart from age, mortality was found to be related to several independent factors: GCS, systolic blood pressure on admission and ISS. In contrast to previous reports that did not find ISS to be an independent predictor for mortality in the elderly, our study clearly showed a significant increase in mortality rates as the ISS rises [21,22]. After adjustment for age, patients with an ISS of 25–75 had a 152 times higher rate of mortality, patients with an ISS of 16–24 had a 24 times increased mortality rate, and patients with an ISS of 9-14 had a 11 times increased mortality rate compared to patients with an ISS < 9. These findings correlate well with the finding of higher ISS levels in the elderly in our series. Perdue and co-workers [19], in a previous non-hip fracture group, also showed that ISS is as good a mortality predictor in the elderly as in the young. Although the percentage of ISS 16–75 was higher in the non-hip fracture group compared to the hip fracture group, its median ISS was lower and correlated well with lower rates of mortality.

Finally, as in previous reports, we demonstrated that GCS and low systolic blood pressure are independent predictors of mortality in the elderly [3,23]. This correlates well with our findings of higher rates of traumatic brain injury in the elderly compared to the young (21.8 vs. 14.4%).

A limitation of this study is that the hip fracture group was not fully evaluated, and hence the true value of its influence on our series is unknown, yet this study does provide practical descriptive data regarding non-hip fracture trauma of the elderly in the last 3 years. Translating the described predictive factors for mortality into an effective community prevention program might help combat the future expected increase in morbidity and mortality associated with trauma of the elderly.

Conclusions

Non-hip fracture-associated trauma in elderly patients is a distinct entity. Falls remain the predominant injury mechanism, and most of the injuries are blunt. ISS increases significantly with age. The average mortality rate among the elderly reaches 6.1%. Age, ISS, GCS and systolic blood pressure on admission are independent predictors of mortality.

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