When Is an Elder Old? Effect of Preexisting Conditions on Mortality in Geriatric Trauma

Michael D. Grossman, MD, Donna Miller, DO, David W. Scaff, DO, and Steven Arcona, PhD

Background: As the U.S. population ages, the number of geriatric trauma victims will continue to grow. Outcomes are known to be worse for these patients, in large part because of preexisting conditions (PECs). The specific impact of various PECs on outcome in geriatric trauma has not been well studied because of heterogeneous data sets and sample sizes.

Methods: We sought to define the impact of clinical variables and PECs on mortality in geriatric trauma by analyzing a large statewide trauma database. We defined geriatric trauma patients as those age ≥ 65. Isolated hip fractures were excluded. We used multiple logistic regression to determine the effect of 21 different PECs on 30-day in-hospital mortality.

Results: Data were abstracted from 33,781 patient records. Overall mortality was 7.6%. For each 1-year increase in age beyond age 65, odds of dying after geriatric trauma increased by 6.8% (95% confidence interval, 6.1-7.5%). When presenting vital signs, Glasgow Coma Scale score, and ISS were controlled, PECs with the strongest effect on mortality were hepatic disease (odds ratio [OR], 5.1), renal disease (OR, 3.1), and cancer (OR, 1.8). Chronic steroid use increased the odds of death after geriatric trauma (OR, 1.6), whereas Coumadin therapy did not.

Conclusion: Considered independently, these data are insufficient to allow withdrawal of care, but this information may be a useful component to help in guiding families faced with difficult decisions after geriatric trauma.

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As the U.S. population ages, the number of elderly patients presenting to trauma centers will continue to increase. The mean age of the subset of the population over age 65 has increased and will continue to do so. This subgroup is more active and mobile than in previous years, increasing the likelihood of traumatic injury. That individuals live longer and are more active is a testament to the increased overall health in this age group. Nonetheless, recent reports suggest that geriatric trauma patients are the fastest growing segment of patients admitted to trauma centers.[1] In addition, geriatric trauma patients have higher rates of morbidity and mortality compared with younger patients with comparable degrees of injury.[2–4] These observations hold for multisystem "major trauma"[2,3,5,6] and unisystem "minor trauma."[7–10] If the elderly population is more active because they are healthier, why are outcomes in geriatric trauma uniformly worse? Stated another way, when is the elder old?

We used a state trauma registry to carry out a descriptive study of geriatric trauma and examine the impact of comorbidity or preexisting conditions (PECs) on outcome. We attempted to define the impact of specific clinical variables and PECs on mortality in an effort to identify patient subsets in which prolonged, technologically intensive care might be futile. We hypothesized that certain PECs would have a profound effect on mortality in geriatric trauma independent of injury severity.

MATERIALS AND METHODS

A 13-year review of a state trauma database was conducted. The registry collects data from all accredited trauma centers within the state, and data submission is mandatory. Criteria for inclusion in the database include a trauma diagnosis (*International Classification of Diseases* codes 800.00–950.00), death, transfer between institutions, hospital stay after injury of ≥ 72 hours, or admission directly to the operating room or intensive care unit. Patients with isolated hip fractures are excluded from analysis. Data were abstracted for demographic and clinical variables including injury mechanism, injury severity, admission vital signs, and PECs. We characterized mild injury as an Injury Severity Score (ISS) < 15, moderate injury as ISS of 15 to 30, and severe injury as an ISS > 30.

We defined geriatric patients as aged ≥ 65. Deaths were defined as those that occurred within the initial period of hospitalization after injury. We defined PECs in accordance with the operative definitions provided for data submission to the state registry (Table 1). We used multiple logistic regression to identify the impact of PECs on in-hospital mortality, adjusting for clinical variables (vital signs and Glasgow Coma Scale [GCS] score) and injury severity (ISS). We excluded patients who were intubated and had a GCS score of 3 at admission, assuming the majority of these patients would die within the first 24 hours of hospitalization, thus minimiz-

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From the Departments of Surgery (M.D.G., D.W.S.) and Geriatrics (D.M., S.A.), St. Lukes Hospital, and Department of Trauma and Surgical Critical Care (M.D.G.), University of Pennsylvania, Bethlehem, Pennsylvania.

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Address for reprints: Michael D. Grossman, MD, Department of Surgery, Division of Trauma and Critical Care, University of Pennsylvania, St. Lukes Hospital, Bethlehem, PA 18015.

Table 1 Definitions of Preexisting Conditions (PECs)

A. Cardiac disease
   1. History of cardiac surgery
   2. Coronary artery disease
   3. Congestive heart failure
   4. Cor pulmonale
   5. Myocardial infarction
   6. Hypertension
B. Diabetes
   1. Insulin-dependent
   2. Non–insulin-dependent but on oral medication
C. Gastrointestinal disease
   1. Peptic ulcer
   2. Gastric or esophageal varices
   3. Pancreatitis
   4. Inflammatory bowel disease
D. Hematologic disease
   1. Acquired coagulopathy
   2. Coumadin therapy
   3. Hemophillia
   4. Preexisting anemia
E. History of psychiatric disorders
F. Immunosuppression
   1. HIV/AIDS
   2. Routine steroid therapy
   3. Transplants
   4. Active chemotherapy
G. Liver disease
   1. Bilirubin > 2.0 mg/dL
   2. Documented history of cirrhosis
H. Malignancy
   1. Undergoing current therapy
   2. Existence of metastasis
I. Musculoskeletal
   1. Rheumatoid arthritis
   2. Systemic lupus erythematosus
J. Neurologic
   1. Spinal cord injury
   2. Multiple sclerosis
   3. Alzheimer's disease
   4. Seizures
   5. Chronic demyelinating disease
   6. Chronic dementia
   7. Organic brain syndrome
   8. Parkinson's disease
   9. Stroke
K. Obesity
L. Pulmonary disease
   1. Documented history with active ongoing treatment
   2. Asthma
   3. COPD
   4. Chronic pulmonary condition
M. Renal disease
   1. Serum creatinine > 2 mg/dL
   2. Dialysis (exclude transplants)
N. Substance abuse
   1. Chronic drug use
   2. Chronic alcohol abuse
O. Pregnancy
P. Prior history of trauma or burn admission

HIV, human immunodeficiency virus; AIDS, acquired immunodeficiency syndrome; COPD, chronic obstructive pulmonary disease.

Table 2 Mechanism of Injury: Fall vs. "All Other"

	Falls	"All Other"
Age (y)	79.1 ± 7.8*	74.9 ± 6.8
Gender		
Male (%)	6617 (30.4)	5923 (49.2)
Female (%)	15,126 (69.6)*	6115 (50.8)
Mortality (%)	1452 (6.7)*	1122 (9.3)
Percentage in ISS group		
<15	82.1	65.3
15–30	16.9	27.5*
>30	1.0	7.2*

* $p < 0.001$.

ing the impact of PECs on outcome. For the purposes of our study, these were considered essentially "nonsurvivable" injuries. χ^2 analysis and t tests were used to analyze differences among means. Data are displayed as the mean ± SD.

RESULTS

From 1986 to 1999, there were 33,781 geriatric trauma patients entered into the state database. Overall 30-day in-hospital mortality was 2,574 of 33,781 (7.6%). Mean age was 77.6 ± 7 years, 37% were men, and 63% were women. Mean ISS for survivors was 10.3 ± 7.4; for nonsurvivors, 23.1 ± 14.4 ($p < 0.001$).

There were 1223 intubated patients who presented with GCS score of 3, of whom 887 (72.5%) died. These patients were excluded from the model in an effort to focus the analysis on the effect of preexisting conditions on in-hospital mortality. We assumed these patients to be "immediate" deaths for whom PECs would have little impact. These patients had a mean ISS of 29 ± 18.

There were 21,743 (64%) patients whose injury mechanism was listed as "fall." This subgroup had a significantly higher proportion of female patients (69.6% vs. 50.8%, $p <$ 0.0001), was older (79.1 ± 8.0 years vs. 74.9 ± 6.8 years, p < 0.001), and had lower average ISS (9.8 ± 6.9 vs. 13.8 ± 11.0, $p < 0.001$) compared with geriatric trauma patients whose injury mechanism was anything other than a fall. In patients whose mechanism of injury was other than a fall, mortality was higher (9.3% vs. 6.7%, $p < 0.001$) and more patients had moderate or high ISS (ISS > 15, 34.7% vs. 17.9%, $p < 0.001$). These data are displayed in Table 2.

When analyzed with respect to injury severity, 25,720 of 31,207 (76%) geriatric trauma patients had mild injury (ISS < 15), and the mortality rate for these patients was 3%. Twenty percent of geriatric trauma patients had moderate injury (ISS of 15–30), with a mortality rate of 18.3%; and 4% had severe injury (ISS > 30), with a mortality rate of 50.1%. Despite the lower overall mortality in patients whose injury mechanism was a fall, those with an ISS of 15 to 30 had a mortality rate of 21.8%, whereas those with all other types of injury in the same ISS group had a mortality of 14.4% ($p <$ 0.001). These data are displayed in Table 3.

Table 3 Injury Severity and Mortality by Mechanism of Injury

	ISS < 15 (%)	ISS 15–30 (%)	ISS > 30 (%)
All patients	758 (3)	1278 (18.3)	538 (50.1)
Falls	547 (3.1)	802 (21.8)*	103 (49.8)
"All other"	211 (2.7)	476 (14.4)*	435 (50.2)

* $p < 0.001$.

Multiple logistic regression analysis was performed to determine the effects of clinical variables and PECs on outcome. The results for the multiple logistic regression model that was established using clinical and demographic variables as well as PECs are displayed in Tables 4 and 5. For each 1-year increase in age at the time of injury, mortality increased by 6.8% (95% confidence interval [CI], 6.1-7.5%). As shown in Table 4, the odds of death were 34% lower for females (95% CI, 28-41%). Systolic blood pressure below 90 mm Hg, and heart rate less than 60 or greater than 120 beats/min were also associated with decreased odds of survival. Independent of these effects, certain PECs were predictors of increased odds of mortality in geriatric trauma patients. The significance of these PECs is seen both in patients with falls and in patients with other mechanisms of injury. The PEC associated with the highest odds ratio for mortality after geriatric trauma was hepatic disease (odds ratio, 5.1; 95% CI, 3.1-8.2), followed by renal disease, cancer, and congestive heart failure (CHF) (Table 6). Increased odds of death are attributed to an immunocompromised state only in patients whose mechanism of injury is *other* than a fall, and increased odds of death attributed to hematologic disease and cancer are observed only for patients whose mechanism of injury *is* a fall. These effects are summarized in Table 5.

DISCUSSION

Multiple studies have documented that geriatric trauma patients do not fare as well their as younger counterparts. Higher complication rates[2,3,11] and their relation to preexisting conditions have been cited as the principal reason for this. Several studies of preexisting conditions in geriatric trauma have concluded that these conditions exert an influence that is age-independent.[12,13] Cancer,[12] renal failure,[12,13] hepatic disease,[13] heart disease, and chronic obstructive pulmonary disease[6] have each been reported as the most significant predictors of an increased risk of dying after geriatric trauma. However, many of these studies are difficult to interpret because the definitions for PECs vary, and most studies are retrospective reviews dependent on chart abstraction or hospital discharge diagnosis.[13] Furthermore, some studies address groups of patients with relatively low injury severity,[6] whereas others "preselect" for higher injury severity by excluding falls[11] or including only those with an ISS above a certain cutoff.[5] Finally, most studies of geriatric trauma have suffered from having relatively low numbers of patients, particularly in the higher injury severity subgroups.

Our goal was to provide a descriptive study of geriatric trauma and define the influence of specific PECs on outcome. Toward that end, we used a state trauma database that provides uniformity in the definition of PECs and a large number of patients for analysis. We applied a multiple logistic regression model to isolate the effect of specific variables. We excluded patients with a GCS score of 3 who were intubated on arrival to the hospital because we felt that in this age group such patients may have essentially nonsurvivable head injuries and would skew the interpretation of the effect of PECs

Table 4 Conditional Odds Ratios for Effect of Clinical and Demographic Variables on Mortality after Geriatric Trauma

Variable	Odds Ratio	LCL	UCL
Age	1.068	1.061	1.075
Gender = female	0.656	0.593	0.725
Race	1.09	0.90	1.30
Systolic blood pressure < 90 mm Hg	3.09	2.50	3.80
Respiration <10, >24 breaths/min	1.68	1.40	1.90
Pulse <60, >120 beats/min	1.68	1.42	1.93
GCS score	0.78	0.77	0.79
ISS	1.098	1.093	1.104

LCL, lower confidence limit; UCL, upper confidence limit.

Table 5 Conditional Odds Ratios for Effect of Preexisting Conditions (PECs) on Mortality in Geriatric Trauma (n = 33,781)

Variable	Odds Ratio	UCL	LCL
Dementia	0.726	0.584	0.896
Neurologic	1.06	0.887	1.26
Cardiac	0.951	0.848	1.06
CHF	1.74	1.46	2.08
Diabetes (IDDM)	1.04	0.788	1.36
Diabetes (NIDDM)	1.05	0.861	1.28
Gastrointestinal	1.14	0.860	1.48
Hematologic	1.22	0.960	1.53
Coumadin	1.21	0.932	1.55
Psychiatric	0.848	0.654	1.09
Immunocompromise	2.05	0.940	4.13
Steroids	1.59	1.03	2.40
Liver disease	5.11	3.09	8.21
Cancer	1.84	1.37	2.45
Arthritis	0.868	0.524	1.37
Obesity	0.704	0.469	1.03
Drug abuse	0.318	0.017	1.66
Alcohol abuse	0.993	0.718	1.35
Pulmonary	1.06	0.770	1.43
COPD	1.49	1.22	1.80
Renal	3.12	2.25	4.28

UCL, upper confidence limit; LCL, lower confidence limit; CHF, congestive heart failure; IDDM, insulin-dependent diabetes mellitus; NIDDM, non–insulin-dependent diabetes mellitus; COPD, chronic obstructive pulmonary disease.

Table 6 **Conditional Odds Ratios: Falls vs. Other Mechanisms of Injury**

Variable	Falls		Other Mechanisms	
	Odds Ratio	UCL, LCL	Odds Ratio	UCL, LCL
Age	1.06	1.05, 1.07	1.08	1.07, 1.09
Sex	0.613	0.538, 0.700	0.740	0.632, 0.866
Systolic BP	2.57	1.75, 3.72	3.74	2.88, 4.85
Respirations	1.57	1.25, 1.96	1.97	1.60, 2.43
Pulse	1.55	1.24, 1.93	1.85	1.48, 2.29
GCS score	0.761	0.743, 0.779	0.823	0.800, 0.846
ISS	1.10	1.10, 1.11	1.08	1.09, 1.10
Liver disease	4.58	2.53, 7.95	6.19	2.20, 16.05
Renal disease	3.16	2.16, 4.54	3.16	1.61, 5.92
Cancer*	2.35	1.67, 3.25	0.879	0.458, 1.59
CHF*	1.99	1.61, 2.44	1.23	0.834, 1.78
COPD	1.49	1.17, 1.88	1.48	1.05, 2.06
Immunosuppression*	0.908	0.243, 2.64	5.14	1.81, 13.21
Hematologic*	1.403	1.074, 1.814	0.723	0.399, 1.240

UCL, upper confidence limit; LCL, lower confidence limit; BP, blood pressure; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.

* Increased odds ratios are statistically significant for one mechanism of injury but not the other.

on in-hospital mortality. Although many such patients in younger age groups are accounted for by the presence of prehospital chemical paralysis and intubation, this clinical presentation is much more ominous in the elderly. Zietlow and Perdue have confirmed that severe closed head injury in elderly patients accounts for a high proportion of trauma deaths within the first 24 hours. In our series, these patients would have accounted for 26% (887 of 3461) of all deaths if they had been included. In addition, because of the large number of patients available for analysis, we were able to differentiate patients by high- and low-energy injury mechanisms (i.e., ground level falls vs. all other mechanisms).

Our study identified that the majority of geriatric patients were injured during a fall and had significantly lower injury severity and higher survival rates than patients whose mechanism of injury was other than a fall. We observed a definite impact of age as a predictor of increased odds of death after geriatric trauma independent of ISS or PECs. This notion has been disputed in the past.[13] ISS had a small impact on survival odds when analyzed as a continuous variable by logistic regression, but when segregated into low, moderate, and high ISS groups, mortality rates were much higher for the moderate and high ISS patients. Our study identified an ISS of 30 as an "LD_{50}" (50% of the geriatric population that sustained this magnitude of injury died) for blunt geriatric trauma independent of mechanism.

The majority of geriatric trauma patients in this and other studies[1] are women. Gender differences are much less pronounced for patients with higher levels of injury and mechanism of injury other than falls. These observations are similar to those in a recent study,[1] and they suggest that women tend to have greater longevity. As they continue to age and out-of-home activity declines, a greater proportion are injured in falls.

The impact of PECs on mortality in geriatric trauma patients was most pronounced for hepatic and renal disease as defined by the criteria. Hypertension and cardiac disease not otherwise specified (i.e., history of myocardial infarction) had no statistical impact on odds of dying, whereas CHF did. Similarly, arthritis had no impact on survival, whereas steroid use, which would be associated with the most severe cases of arthritis, did. Coumadin had no statistical impact on odds of death irrespective of mechanism. This observation is in agreement with a recent study.[14]

Dementia and psychiatric disorders appeared to confer a protective effect on likelihood of mortality. Previous work from our institution[15] suggests that these two PECs are not accurately identified as premorbid conditions in the trauma patient. Using multiple logistic regression, that study identified dementia as a predictor of increased in-hospital mortality when controlling for age, ISS, gender, and place of injury (institution vs. noninstitution). Of note, the study found only a 5.2% incidence of this PEC in trauma patients over the age of 65, well below the 10% incidence reported by Evans et al.[16] When compared with other PECs that may have been more accurately identified, the effect of dementia on outcome is diluted. Opportunities to more accurately screen for dementia in geriatric trauma exist and are an important adjunct to trauma prevention, particularly in those patients involved in motor vehicle collisions.

When the effect of PECs was examined for patients with falls versus all other mechanisms of injury, hepatic and renal disease continue to produce the greatest increase in the odds of dying. Chronic obstructive pulmonary disease produces nearly identical increases in odds of death irrespective of mechanism. CHF and cancer *remain* predictive only in patients whose injury mechanism is a fall and hematologic abnormalities *become* predictive of increased odds of death *only* in patients who fall. Immunosuppression produces statistically increased odds of dying only in patients whose injury mechanism is *other* than a fall. The wide confidence intervals are attributable to a relatively low number of patients with this PEC (n = 75). In patients who fall, there are six PECs associated with an odds ratio of greater than 1 with respect to mortality. For those with other injury mechanisms, there are four, one of which is immunosuppression. It is tempting to speculate that because geriatric patients who fall are older, more infirm, and less severely injured than those with other injury mechanisms, PECs play more of an aggregate role when these patients have a poor outcome. This contention is supported by our observation that mortality is significantly higher in elders who sustain serious injuries in falls (ISS of 15–30) compared with patients in the same ISS category but with other mechanisms of injury. Mortality rates in the very high ISS group ($>$ 30) are nearly identical, suggesting that for these patients, magnitude of injury becomes the overriding determinant of outcome.

The limitations of this study are that it is retrospective. A model was developed that might allow prediction of mortality in geriatric trauma patients, but it will have to be tested prospectively or against a "split" data set. Until this is done, the hypotheses are supported only by good descriptive data. Use of odds ratios are somewhat problematic: as the overall population is subclassified (i.e., falls vs. nonfalls) the number of patients with various PECs becomes smaller and confidence intervals widen. Finally, as is true of all previous studies of geriatric trauma, the effect of patient and family predetermination is uncontrolled. The latter is particularly important in geriatric trauma, perhaps more so for geriatric trauma patients with significant comorbidity. Such patients might be expected to have a living will or an understanding with family members that prolonged technologically intensive care would not be in their best interests. Examples include a decision not to allow surgery for subdural hematoma or intubation for respiratory failure. The effect of this uncontrolled variable might be twofold: on the one hand, observed mortality might be higher for low levels of injury severity; on the other, mortality may not be a completely undesirable outcome when it is the result of a well-thought-out predetermination plan.

The study does provide practical descriptive data regarding geriatric trauma and the effect of PECs on outcome. The data support the hypothesis that certain PECs (hepatic disease and renal failure) have a major impact on outcome independent of ISS, and the impact may be more significant in patients who are seriously injured after a fall as opposed to other mechanisms. Given that the combination of advanced age, certain PECs, and high ISS are associated with markedly increased odds of death, prolonged application of technologically intensive medical care may be viewed in some cases as prolonging death. Although withdrawal of care is an individual decision reached by physicians in concert with family members, these data provided objective support for such a decision in a specific patient subgroup. In contradistinction to the conclusions reached by many studies[6,11,17] of geriatric trauma and critical illness, aggressive care for these patients may *not* always be justified.

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