Mortality in Elderly Patients After Cervical Spine Fractures

By Mitchel B. Harris, MD, William M. Reichmann, MA, Christopher M. Bono, MD, Kim Bouchard, BA, Kelly L. Corbett, BA, Natalie Warholic, MA, Josef B. Simon, MD, Andrew J. Schoenfeld, MD, Lawrence Maciolek, MD, Paul Corsello, BA, Elena Losina, PhD, and Jeffrey N. Katz, MD, MSc

Investigation performed at the Department of Orthopedic Surgery and the Division of Rheumatology, Immunology and Allergy, Brigham and Women's Hospital, Boston, Massachusetts

Background: Despite an increased risk of cervical spine fractures in older patients, little is known about the mortality associated with these fractures and there is no consensus on the optimal treatment. The purposes of this study were to determine the three-month and one-year mortality associated with cervical spine fractures in patients sixty-five years of age or older and to evaluate potential factors that may influence mortality.

Methods: We performed a retrospective review of all cervical spine fractures in patients sixty-five years of age or older from 1991 to 2006 at two institutions. Information regarding age, sex, race, treatment type, neurological involvement, injury mechanism, comorbidity, and mortality were collected. Overall risk of mortality and mortality stratified by the above factors were calculated at three months and one year. Cox proportional-hazard regression was performed to identify independent correlates of mortality.

Results: Six hundred and forty patients were included in our analysis. The mean age was eighty years (range, sixty-five to 101 years). Two hundred and ninety-four patients (46%) were male, and 116 (18%) were nonwhite. The risk of mortality was 19% at three months and 28% at one year. The effect of treatment on mortality varied with age at three months (p for interaction = 0.03) but not at one year (p for interaction = 0.08), with operative treatment being associated with less mortality for those between the ages of sixty-five and seventy-four years. A higher Charlson comorbidity score, male sex, and neurological involvement were all associated with increased risk of mortality.

Conclusions: Operative treatment of cervical spine fractures is associated with a lower mortality rate at three months but not at one year postoperatively for patients between sixty-five and seventy-four years old at the time of fracture.

Level of Evidence: Prognostic Level II. See Instructions to Authors for a complete description of levels of evidence.

Persons over the age of sixty-five years are the fastest growing segment of the U.S. population¹. Older individuals are often active and consequently at risk for traumatic musculoskeletal injuries. The most common of these injuries include fractures of the distal end of the radius, proximal part of the humerus, pelvis, hip, and cervical spine².

When spine and extremity fractures occur in association with visceral injuries in older patients, the cumulative injury severity is greatly magnified^{3,4}. Furthermore, the presence of multiple medical comorbidities often leads to an increased risk

of complications⁴. All of these factors influence an elderly patient's ability to survive a traumatic event³.

These observations underscore the importance of examining the association between fracture and mortality in the elderly. The best studied relationship between injury type and mortality rate is hip fracture. Jensen and Tøndevold found a one-year mortality of 27% for elderly patients after a hip fracture⁵. These results are consistent with those in several other studies that have similarly documented one-year mortality rates ranging from 27% to 33%^{6,7}. These findings have subsequently shaped current treatment algorithms in which

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early surgical treatment has been demonstrated to positively influence survival^{8,9}.

Mortality associated with cervical spine fractures in elderly patients is less well studied^{4,10-13}. Recently, several studies have found a risk of acute (in-hospital) mortality of >20% for elderly patients with isolated cervical spine fractures^{14,15}. While osteoporosis and ankylosis are generally thought to place elderly individuals at increased risk for cervical spine fractures^{15,16}, there is little published information on the rate of mortality after these injuries. This deficiency in the literature contributes to a lack of consensus on the optimal treatment of cervical fractures in elderly individuals.

The objective of this investigation was to determine the three-month and one-year mortality associated with cervical spine fractures in patients sixty-five years of age or older. Secondarily, we sought to evaluate potential factors that might influence the risk of mortality, including associated neurological injury, the extent of associated trauma (isolated compared with polytrauma), race, sex, treatment type, and the presence of medical comorbidities.

Materials and Methods

Sample

All cervical spine fractures (International Classification of Diseases, Ninth Revision [ICD-9] codes 805.01 to 805.07, 806.00 to 806.09, and 806.10 to 806.19) that occurred in pa-

tients sixty-five years of age or older from 1991 through 2006 and were treated at either of two institutions (Massachusetts General Hospital and Brigham and Women's Hospital) were identified with use of the institutions' Research Patient Data Registry. The Research Patient Data Registry is a data warehouse that can be queried to identify patients on the basis of clinical and demographic information that has been recorded for all patients treated at the two institutions, both of which are level-I trauma centers. The Research Patient Data Registry links each patient to the National Death Index and therefore provides complete and accurate data on mortality, even if the patient has moved out of state, or has otherwise been lost to clinical follow-up. The study was approved by our institutional review board.

For all patients who had ICD-9 codes indicating a cervical spine fracture, we examined the radiographic report in the electronic medical record. To be considered for this analysis, the radiographic report had to document a cervical fracture or dislocation, including at the cervicothoracic junction.

Additional Data Elements

For each patient with a confirmed fracture, electronic medical records were further reviewed to gather additional information concerning the patient and the fracture. The information included age; date of injury; fracture level; fracture type; associated injuries; treatment type (operative or nonoperative);

Fig. 1

Algorithm for identifying eligible study patients.

race (white or nonwhite); sex; evidence of associated neurological injury (defined as injury to the nerve roots from C5 through T1 or a spinal cord injury [complete or incomplete]); the presence or absence of thirteen medical comorbidities, weighted according to severity (with use of the Charlson comorbidity index)¹⁷; and mortality. These variables were selected for analysis because we hypothesized on the basis of clinical experience and limited literature that they might be associated with mortality.

We obtained a Charlson comorbidity index score to summarize the burden of comorbid illnesses. This index has been validated extensively as a predictor of mortality, for example, in patients with end-stage renal disease and coronary bypass surgery¹⁷⁻²⁰. It has also been utilized to stratify functional outcomes after total joint replacement in a study comparing volume and outcomes^{21,22}. The Charlson index was classified into three groups (0, 1, and 2+). Because of a high prevalence of missing data (22%; 139 of 640 patients) for the Charlson comorbidity index, we added a category for missing data when analyzing this factor in multivariate regression analyses.

The mechanism of injury was evaluated with two separate variables derived from the medical record. The first analyzed isolated injury (cervical spine injury only) compared with polytrauma (cervical spine with concomitant injuries). The second mechanism-of-injury variable analyzed high-energy compared with low-energy injuries. High-energy injuries included motor vehicle accidents, a pedestrian being struck by a motor vehicle, or a fall down the stairs or from a height of >3 m. Low-energy injuries included falls from a sitting or standing position, an assault, or a penetrating trauma.

Fracture type was classified into three categories: (1) an upper cervical fracture (occipital to C2) with associated dens involvement, (2) an upper cervical fracture without dens involvement, and (3) a lower cervical fracture (C3-C7).

Statistical Analysis

To be included in the analysis, each patient had to be at least sixty-five years old at the time of injury and have radiographic documentation of an acute cervical spine fracture in his or her electronic medical record. The date of injury was required as well in order to document the risk of mortality at three and twelve months after the injury. Age was stratified into three groups: sixty-five to seventy-four years, seventy-five to eighty-four years, and eighty-five years or older.

The mortality rate at three months and at one year were calculated for the entire sample and for the different subgroups specified above. Ninety-five percent confidence intervals were calculated with use of the normal approximation to the binomial distribution. We hypothesized that age would modify the effect of treatment on the risk of mortality so we performed the Breslow-Day test of homogeneity to address the interaction between age and treatment on mortality. Cox proportional hazard regression was

TABLE I Characteristics of the Entire Sample of 640 Patients

Characteristic	No. (%) of Patients*
Age (yr)	
65-74	202 (31.6)
75-84	245 (38.3)
85+	193 (30.2)
Sex	
Male	294 (46.0)
Female	345 (54.0)
Race	
White	524 (81.9)
Nonwhite	116 (18.1)
Charlson comorbidity score	
0	184 (28.8)
1	130 (20.3)
2+	187 (29.2)
Missing	139 (21.7)
Treatment	
Operative	113 (17.7)
Nonoperative	527 (82.3)
Fracture type	
Upper cervical spine with dens involvement	245 (38.3)
Upper cervical spine without dens involvement	152 (23.7)
Lower cervical spine	243 (38.0)
Neurological involvement	
Yes	44 (6.9)
No	595 (93.1)
Trauma type	
Single trauma	400 (62.5)
Polytrauma	240 (37.5)
Mechanism of injury	
High energy	282 (46.8)
Low energy	320 (53.2)

*Data were missing with regard to sex and neurological involvement for one patient each and with regard to mechanism of injury for thirty-eight patients.

performed to determine independent risk factors for death and to adjust for possible confounding of the associations between treatment and mortality by medical comorbidities, neurological injury, polytrauma compared with isolated injury, sex, and race.

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TABLE II Three-Month and One-Year Mortality Rates by Specified Risk Factors

	3-Mo Mortality Risk (95% Confidence Interval) (%)	1-Yr Mortality Risk (95% Confidence Interval) (%)
Overall	19.2 (16.2, 22.3)	27.7 (24.2, 31.1)
Age (yr)		
65-74	9.9 (5.8, 14.0)	18.3 (13.0, 23.7)
75-84	18.8 (13.9, 23.7)	26.5 (21.0, 32.1)
85+	29.5 (23.1, 36.0)	38.9 (32.0, 45.7)
Sex		
Male	20.7 (16.1, 25.4)	32.0 (26.6, 37.3)
Female	18.0 (13.9, 22.0)	24.1 (19.5, 28.6)
Race		
White	19.1 (15.7, 22.4)	28.1 (24.2, 31.9)
Nonwhite	19.8 (12.6, 27.1)	25.9 (17.9, 33.8)
Charlson comorbidity score		
0	10.9 (6.4, 15.4)	16.8 (11.4, 22.3)
1	21.5 (14.5, 28.6)	29.2 (21.4, 37.0)
2+	24.6 (18.4, 30.8)	37.4 (30.5, 44.4)
Treatment		
Operative	17.7 (10.7, 24.7)	27.4 (19.2, 35.7)
Nonoperative	19.5 (16.2, 22.9)	27.7 (23.9, 31.5)
Fracture type		
Upper cervical spine with dens involvement	19.6 (14.6, 24.6)	28.6 (22.9, 34.2)
Upper cervical spine without dens involvement	19.7 (13.4, 26.1)	25.0 (18.1, 31.9)
Lower cervical spine	18.5 (13.6, 23.4)	28.4 (22.7, 34.1)
Neurological involvement		
Yes	31.8 (18.1, 45.6)	50.0 (35.2, 64.8)
No	18.3 (15.2, 21.4)	26.1 (22.5, 29.6)
Trauma type		
Single trauma	18.3 (14.5, 22.0)	28.8 (24.3, 33.2)
Polytrauma	20.8 (15.7, 26.0)	25.8 (20.3, 31.4)
Mechanism of injury		
High energy	17.0 (12.6, 21.4)	24.5 (19.5, 29.5)
Low energy	22.5 (17.9, 27.1)	31.6 (26.5, 36.7)

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Results

Study Sample

The Research Patient Data Registry query identified 1347 patients who sustained a cervical spine fracture between 1992 and 2006. Of the 1347 patients identified, 529 (39%) were excluded because there was no evidence in the chart that they had actually sustained a cervical fracture; an additional 109 (8%) were excluded because they were younger than sixty-five years of age at the time of injury; and the remaining sixty-nine patients (5%) did not have a recorded date of injury, which prevented determination of their survival status at three months and one

year after the injury. After excluding these patients, 640 patients (48% of the initially identified cohort) were included in this analysis (Fig. 1). The mean age (and standard deviation) of the eligible patients at the time of fracture was 80 ± 8 years (range, sixty-five to 101 years). One hundred and sixteen patients (18%) were nonwhite, and 294 (46%) were male. Two hundred and forty patients (38%) sustained a cervical spine fracture associated with polytrauma. One hundred and thirteen (18%) were treated operatively for the cervical spine injury, and forty-four patients (7%) had neurological injury in association with their fracture. Thirty-eight percent had an upper cervical fracture with an associated dens fracture, 24% had an upper cervical fracture without an associated dens fracture, and 38% had a lower cervical fracture (Table I).

Three Month Risk of Mortality by Treatment and Age

Fig. 2-A

One Year Risk of Mortality by Treatment and Age

Fig. 2-B

Three-month mortality (Fig. 2-A) and one-year mortality (Fig. 2-B) stratified by treatment (operative compared with nonoperative) and patient age.

Mortality at Three Months

Mortality at three months for the entire cohort was 19% (95% confidence interval, 16% to 22%). The risk of mortality at three months increased with greater patient age at the time of fracture. Patients between sixty-five and seventy-four years old had a three-month mortality of 10%, patients between seventy-five and eighty-four years old had a three-month mortality of 19%, and patients who were eighty-five years or older had a three-month mortality of 30% (Table II).

The overall risk of mortality was similar between the treatment groups (operative compared with nonoperative) at three months (18% and 20%, respectively). However, further analysis indicated that age played a critical role in the relationship between treatment and three-month mortality (Breslow-Day p for interaction = 0.03). That is, at three months, the risk of mortality for those in the youngest age group (sixty-five to seventy-four years old) was lower among those treated operatively than among those treated nonoperatively. In contrast, for those in the oldest age group (more than eighty-five years old),

the risk of mortality was higher among those treated operatively than among those treated nonoperatively (Fig. 2-A).

At three months, a higher risk of mortality was seen in patients who had a neurological injury in association with the fracture compared with those who were neurologically intact (32% and 18%, respectively; $p = 0.03$). We also found a higher risk of mortality in patients who had a higher Charlson comorbidity score. Patients with a score of 0 had a three-month risk of 11%, while patients with a score of 1 had a three-month risk of 22%. Patients with a score of ≥ 2 had a three-month risk of 25%. We did not find an association between fracture type and mortality. Those with an upper cervical fracture with dens involvement had a 20% risk of mortality at three months. Those with an upper cervical fracture without dens involvement (20%) and those with a lower cervical fracture (19%) had similar risks of mortality at three months. We did not identify an effect of sex, race, trauma type, and mechanism of injury on mortality at three months (Table II).

Mortality at One Year

Mortality at one year for the entire cohort was 28% (95% confidence interval, 24% to 31%). One-year mortality increased with greater patient age. Patients between sixty-five and seventy-four years old had a one-year mortality of 18%. The one-year risk increased to 27% for the patients between seventy-five and eighty-four years old, while it increased to 39% for those eighty-five years of age or older.

At one year, mortality for the operative and nonoperative groups was nearly identical (27% and 28%, respectively). Although not significant, the one-year mortality rates among operatively treated patients compared with nonoperatively treated patients were affected by the age of the patient at the time of the fracture (Breslow-Day p for interaction = 0.08). Similar to three-month mortality, at one year, the risk of mortality for those in the youngest age group was lower among those who were treated operatively, while those in the oldest age group who underwent surgery demonstrated a higher risk of mortality (Fig. 2-B).

At one year, a higher risk of mortality was seen in patients who had a neurological injury in association with the fracture than in those who were neurologically intact (50% and 26%, respectively). We also found a higher risk of mortality in patients who had a higher Charlson comorbidity score. Patients with a score of 0 had a one-year risk of 17%, while patients with a score of 1 had a one-year risk of 29%. Patients with a score of ≥ 2 had a one-year risk of 37%. Those with an upper cervical fracture with dens involvement (29%), upper cervical fracture without dens involvement (25%), and lower cervical fracture (28%) had similar risks of mortality at one year. Sex, race, type of fracture, trauma type, and mechanism of injury had no effect on risk of mortality at one year (Table II).

Multivariate Analysis

The Cox proportional-hazard regression analysis (Table III) demonstrated that, for both operatively and nonoperatively

TABLE III Results of the Multivariate Analysis

	Hazard Ratio	95% Confidence Interval
Treatment and age		
Nonoperative between ages of 65 and 74 yr	1.0	Reference
Nonoperative between ages of 75 and 84 yr	1.3	0.9, 1.9
Nonoperative and ≥ 85 yr	2.2	1.6, 3.1
Operative between 65 and 74 yr	0.4	0.2, 0.8
Operative between 75 and 84 yr	1.1	0.7, 1.8
Operative and ≥ 85 yr	2.4	1.4, 4.2
Sex		
Female	1.0	Reference
Male	1.4	1.1, 1.8
Race		
White	1.0	Reference
Nonwhite	1.1	0.8, 1.5
Charlson comorbidity score		
0	1.0	Reference
1	1.7	1.2, 2.4
≥ 2	1.8	1.3, 2.5
Missing	1.4	1.0, 2.0
Trauma type		
Single trauma	1.0	Reference
Polytrauma	0.9	0.7, 1.1
Neurological involvement		
No	1.0	Reference
Yes	2.1	1.4, 3.2
Fracture type		
Upper cervical spine with dens involvement	1.0	Reference
Upper cervical spine without dens involvement	0.9	0.7, 1.3
Lower cervical spine	1.0	0.7, 1.3

treated patients, mortality increased with age. Additionally, the effect of treatment differed according to age, although the interaction between age category and treatment was not significant ($p = 0.06$). Specifically, a protective effect of surgical stabilization was demonstrated in the patients between the ages of sixty-five and seventy-four years (hazard ratio, 0.4; 95% confidence interval, 0.2 to 0.8). However, this protective effect was not seen in the older age groups since the hazard ratios for those treated without surgery and those treated with surgery were similar for specific age groups. A higher Charlson comorbidity score was associated with increased mortality. Patients with a score of 1 (hazard ratio, 1.7; 95% confidence interval, 1.2 to 2.4) or a score of ≥ 2 (hazard ratio, 1.8; 95% confidence interval, 1.3 to 2.5) were at a higher risk of death compared with those with a score of 0. Male sex (hazard ratio,

1.4; 95% confidence interval, 1.1 to 1.8) and neurological involvement (hazard ratio, 2.1; 95% confidence interval, 1.4 to 3.2) were also associated with an increased risk of death. Race, fracture type, trauma type, and mechanism of injury were not associated with mortality in this sample.

Discussion

The two most common mechanisms for cervical spine injury in the elderly are low-energy falls from a standing height and high-energy motor-vehicle collisions^{10-12,23,24}. The incidence, prevalence, and clinical outcomes of low-energy and isolated cervical fractures have not been well studied^{11,25}. Several investigations have demonstrated that elderly patients with a low-energy cervical spine fracture demonstrate outcomes similar to younger patients with a high-energy fracture^{12,23,25,26}. The presumed reasons for this trend include a reduction in functional reserve, a higher risk of airway compromise and urinary tract infections, and an increased risk of associated cardiac events in older people. This relationship is perhaps best demonstrated by the bimodal distribution of upper cervical injuries such as type-II odontoid fractures^{10,12,25,27}.

The bulk of published data addressing the prognosis after cervical fractures in elderly patients has consisted of comparisons of different treatment methods. Those studies did not take into account any of the potential baseline prognostic disparities between young and old patients sustaining similar fractures.

Despite inadequate baseline prognostic data, these and other reports that cast nonoperative therapy unfavorably have influenced current treatment trends, which often recommend surgery unless surgery is not thought to be a feasible option^{28,29}. However, the association between method of treatment and mortality in the current study was not very strong when adjusting for potential confounders (Table III). Furthermore, it appears that this association, albeit weak, varies according to the age of the patient (Fig. 2-A). With these observations, we suggest a strategy tailored to each patient's presentation.

When interpreting the current mortality rates, it is important to note that they are inclusive of, and not additive to, the underlying risk of dying in these age groups. The current study was not designed to compare mortality rates with those in matched controls who did not have a cervical spine fracture. However, a comparison of the current data with national mortality data provides a crude estimate of the additive effect of cervical fracture. In the United States, the death rate for persons from sixty-five to seventy-four years old was 2247 per 100,000 per year for the years 2002, 2003, and 2004 (2.2% per year)²⁰. Similarly, the death rate was 5.3% per year for persons seventy-five to eighty-four years old and 13.9% per year for persons eighty-five years of age or older. Taking patients eighty-five years and older (oldest group in the current study) as an example, the recorded one-year risk of death of 39% is almost threefold higher than the population-based mortality for this age group. Our data cannot determine whether the excess mortality is due to the cervical spine fracture alone or to other factors such as medical comorbidities.

It has been suggested that operative intervention for elderly patients with a cervical spine fracture reduces morbidity and mortality^{23,25,28,29}. Although not specifically designed to compare treatment types, the current study does not support that broad recommendation. Overall, surgical treatment was associated with 30% lower mortality in the multivariate analysis that adjusted for comorbidities and other potential confounders. Thus, the association between treatment type and outcome is complex and does not support simple global treatment recommendations.

In our view, the most salient message from the current analyses is that mortality rates at three and twelve months following a cervical spine fracture are high, and when all factors are taken into account, the presence and number of comorbid illnesses are the most potent predictors of mortality (Table III). Mortality rates increased from three months to one year in patients with a greater number of comorbidities. This finding might be explained by the development of non-fracture-related events. Our results run counter to those of previous studies that found no association between an increase in mortality rate and the number of baseline comorbidities¹⁴.

Our study has substantial limitations. Data pertaining to fracture pattern and the exact type of treatment (e.g., soft collar compared with halo treatment and an anterior compared with a posterior surgical approach) were not collected. Including this information in the analysis might have allowed more meaningful conclusions regarding mortality risk for a particularly problematic injury type, such as type-II odontoid fractures, or the relative safety of cervical collars compared with halo-vest immobilization. Surgical complication data were also incomplete. Additionally, a retrospective review cannot discern the reasons behind the management decisions nor can we infer the number of hospital transfers after "failed nonoperative management." However, the two institutions whose records were utilized are both regional and national referral centers, so it is quite possible that some of the management issues were dictated by the prior course of treatment. Also, our case identification process could conceivably have missed fractures that were not coded correctly. Nearly 40% of the cases identified by ICD-9 codes as potentially representing cervical spine fracture were not confirmed as a fracture on medical record review. This observation is consistent with the literature comparing discharge data with information gleaned from chart review and underscores the importance of confirmation of fracture diagnoses in database analyses such as ours³⁰⁻³².

The analysis was neither prospective nor randomized, which limits inferences about the outcomes of surgical compared with nonsurgical care. Data about the specific causes of death were not collected. This information could have elucidated the relative proportion of patients for whom mortality was specifically related to the fracture or fracture treatment.

In conclusion, the present study offers a foundation for a deeper understanding of the factors that influence the risk of death following these cervical spine fractures in elderly patients. Mortality rates are high, >27% at one year following cervical spine fracture, and increase with age and comorbid conditions. The chosen method of treatment for these injuries

(operative or nonoperative) should not be emphasized to the patient or the family as the critical determinant of either short-term (three-month) or long-term (one-year) mortality. It is but one variable to be considered in the decision-making process. This information may be useful in counseling patients, family members, and caretakers to develop more realistic treatment expectations in this fragile population. ■

Mitchel B. Harris, MD
William M. Reichmann, MA
Christopher M. Bono, MD

Kim Bouchard, BA
Kelly L. Corbett, BA
Natalie Warholic, MA
Josef B. Simon, MD
Andrew J. Schoenfeld, MD
Lawrence Maciolek, MD
Paul Corsello, BA
Elena Losina, PhD
Jeffrey N. Katz, MD, MSc
Department of Orthopedic Surgery (M.B.H., W.M.R., C.M.B., K.B., K.L.C., N.W., J.B.S., A.J.S., L.M., P.C., E.L., and J.N.K.), and the Division of Rheumatology, Immunology and Allergy (J.N.K.), Brigham and Women's Hospital, 75 Francis Street, Boston, MA 02115.
E-mail address for M.B. Harris: mbharris@partners.org

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