Improving life expectancy: A 'broken neck' doesn't have to be a terminal diagnosis for the elderly

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ABSTRACT

Background Elderly patients with cervical spine fractures require optimal care. Treatment with a cervical collar or halo instead of surgical fixation may increase mortality. This investigation intends to describe the life expectancy after injury and evaluate the impact of surgical intervention on mortality.

Methods Patients ≥65 years, with traumatic cervical spine fractures without cord injury were identified in the 1995–2009 California Office of Statewide Health and Planning database. Those with halo placement or surgical spine fixation were identified. Primary outcome was death, studied at the initial admission, 30 days, 1 year, and the entire study period. Univariate and multivariate regressions were performed to identify predictors of death. Kaplan-Meier survival curves were used to describe life expectancy after injury.

Results 10 938 patients were identified. Mortality rate was 10% during the initial admission, 28% at 1 year and 50% during the entire study period. A halo was placed in 14% of patients and 12% underwent surgical fixation. Mortality rates during the initial admission were 11% for patients without an intervention, 7% with halo placement and 6% with surgical fixation; at 1 year, these increased to 30%, 26% and 19%, respectively. At 1 year, more than one in four patients above 75 years of age will die. At 1 year spine fixation, female gender and admission to a trauma center predicted a lower risk of death at 1 year (OR 0.59, 0.68; p<0.001 and OR 0.89; p=0.02, respectively). Having a complication, fall mechanism, and traumatic brain injury (OR 1.84, 1.33, 1.37; p<0.001, respectively) were predictors of a higher risk of death. Halo use had no impact on death at 1 year (OR 0.98; p=0.77).

Discussion Mortality rates after cervical spine fracture in the elderly is high. Surgical fixation is associated with improved survival; remaining true after adjusting for age and comorbidities; suggesting that surgical fixation may improve outcomes in the elderly.

Level of evidence Level IV.

BACKGROUND

Adults 65 years of age and above constitute the fastest growing segment of the population in the USA per the National Census Bureau.[1] In 2015, this age group represented 30% of trauma admissions reported in the National Trauma Databank Annual Report.[2] In light of these facts, determining how to optimally care for this growing population of elderly patients with trauma is of the utmost importance.

At this time, there is continued controversy regarding the most effective way to manage cervical spine fractures in the elderly. Questions include the timing and selection of operative candidates as well as the optimal form of external bracing. Patients kept in a cervical collar or halo may have significantly limited mobility, dysphagia, and airway compromise,[3–5] potentially increasing morbidity and mortality. Mortality for cervical spine fractures in the elderly has been reported with great variability ranging from 0% to 40% and differing between treatment modalities.[6-8]

One of the largest trials comparing all three modalities of treatment for cervical spine fractures in the elderly included only 156 patients,[8] emphasizing the need for larger trials to better define outcomes and guide treatment selection for these patients. Using a large administrative database with the ability to follow patients over time, this investigation intends to describe the life expectancy after such an event. In addition, we will evaluate the impact of treatment modality on mortality after injury.

METHODS

A retrospective analysis of the California Office of Statewide Health Planning and Development Discharge (OSHPD) database from January 1995 to December 2009 was performed. OSHPD is an administrative database with mandatory reporting on every inpatient hospital encounter from all non-federal hospitals licensed in the state of California. Data submitted for each admission include patient demographics, insurance status, disposition and up to 25 diagnosis and 20 procedure International Classification of Disease version 9 (ICD-9) codes. Additional information on the OSHPD database can be obtained at www.oshpd.ca.gov.

All patients aged 65 and above with ICD-9 diagnosis codes for traumatic cervical spine fractures were identified. Those with spinal cord injuries were excluded (online Supplementary appendix A). Management interventions for cervical spine fractures were defined as rigid collar, halo application or surgical fixation. Halo application and surgical fixation data were obtained using the ICD-9 procedure codes for these interventions (online Supplementary appendix A). Any patient who was not identified as having one of these interventions was assumed to be managed in a rigid collar only.

The primary outcome of the study was mortality. Mortality rates were categorized as death during the initial hospitalization, 30 day, 1 year, and at any time during the entire 15-year study period. The odds of mortality at these time points were also analyzed by univariate and multivariate logistic regressions. The OSHPD database is linked to the National

Death Index Registry by the California OSHPD Office. This linkage allows detection of mortality as an outcome, regardless of whether or not death occurred in a hospital. Primary cause of death based on the death certificate is available; however, due to the known inaccuracy of these data we did not analyze cause of death.

Patient variables used in our analysis included age, gender, race (non-Hispanic white, Hispanic, Black, Asian and other), Charlson Comorbidity Index (CCI), and the survival risk ratio (SRR). The SRR is a surrogate for Injury Severity Score and is based on estimates of survival associated with each ICD-9 injury code.[9][10] Other associated clinical diagnoses identified based on ICD-9 codes (online Supplementary appendix A) included traumatic brain injury (TBI), obesity, dementia or dysphagia. Due to limitations of the database, severity of TBI could not be analyzed. A complication was defined as a diagnosis of pneumonia, venous thromboembolism or myocardial infarction during the initial hospitalization. Patients were defined as having polytrauma if they had any other traumatic ICD-9 diagnosis code associated with their initial admission. Mechanism of injury was classified using ICD-9 E-codes for fall; ground level or from a height versus any other mechanism. Whether or not the initial admission was to a designated trauma center was also analyzed for each patient.

To describe the life expectancy after cervical spine fracture, Kaplan-Meier survival curves were used to analyze risk of death over time after cervical spine fracture. Given the fact that life expectancy is inherently shorter with increasing age, the population was divided into subgroups defined as ages 65–74, 75–84, 85-94 and >95 for this univariate analysis.

Univariate analysis was performed using Pearson's X^2 test for categorical variables. Univariate logistic regressions were done to analyze predictors of death at the initial admission, 30 days and 1 year. Multivariate logistic regressions were then performed for the same time points. Multivariate Cox proportional hazard analysis was performed to evaluate risk of death during the entire study period. Selection of variables for the multivariate analyses was based on significant findings from the univariate regressions. The multivariate regression analyses for death were adjusted for age, gender, race, complications, treatment modality, polytrauma, TBI, traditional SRR, dysphagia, dementia, tracheostomy, gastrostomy, obesity, trauma center admission, and mechanism of injury. The p values were considered significant at <0.05.

RESULTS
From January 1, 1995 to December 31, 2009, there were 10 937 patients who met the inclusion criteria. Among this population, 8091 (74.0%) were managed with a rigid collar, 1543 (14.1%) with a halo and 1304 (11.9%) underwent surgical fixation. Demographics for the overall patient population are outlined in table 1. Falls accounted for 56.2% of all injuries and 69.9% of falls were ground level. Polytrauma was identified in 65.1% of the patient population. At least one complication occurred in 18.9% of patients during the initial admission, with the rate of pneumonia at 12.2%, venous thromboembolism 1.4%, and myocardial infarction 7.3%. Additional clinical variables identified in the study population were dementia (2.6%), dysphagia (6.1%), tracheostomy (4.0%), and gastrostomy (3.6%). Half (50.2%) of the patients were admitted and treated at a designated trauma center.

Mortality rate during the initial hospitalization was 9.87% and 30-day mortality was 14.4%. Long-term mortality was

Table 1 Study population demographics

	Overall %
Number of patients	n=10 938
Females	53.5
Males	46.5
Mean Age	80.2 years, SD 8.1
Race	
Non-Hispanic White	80.9
Black	8.7
Hispanic	2.7
Asian	5.5
Other	2.2
Insurance status	
Self-pay	0.7
Medical	2.2
Medicare	85.3
Private	11.7

28.29% at 1 year, and 50.32% for the entire 15-year study period. Kaplan-Meier survival curves were created for death based on age at the time of admission. With each decade increase in age, there was a significantly decreased survival rate in the study population (figure 1).

Subgroup analysis for mortality among patients managed with a rigid collar, halo or surgical intervention at each of these time points (initial hospitalization, 30 day, 1 year, and overall study period) was also performed (table 2). The lowest morality rates were in the group of patients treated with surgical fixation. These findings in addition to other patient variables assessed by treatment modality are summarized in table 2.

For the initial hospitalization, significant predictors of death (p≤0.05) based on univariate logistic regressions included having a complication, polytrauma, CCI of 1 or ≥2, dysphagia, need for tracheostomy or gastrostomy, having a TBI, and admission to a trauma center (see table 3). In addition, compared with those aged 65–74 every decade increase in age predicted mortality; age 75–84, OR 1.73; age 85–94, OR 2.65; and age >95, OR 2.76. Patient factors that were significantly protective against mortality (p≤0.05) were management with a halo or surgical
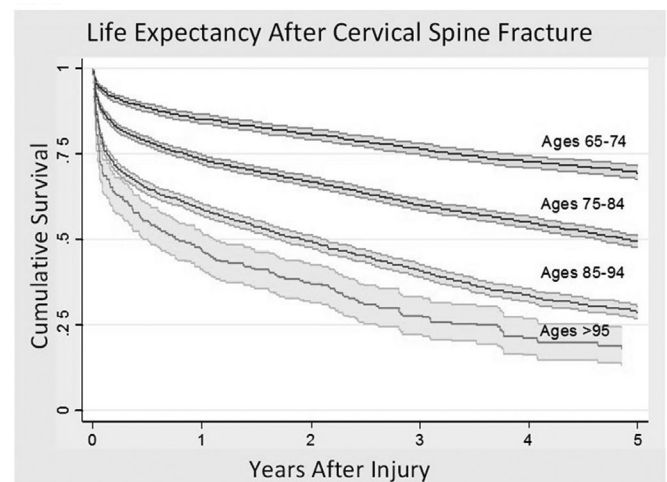

Figure 1 Kaplan- Meier survival curves for patients after initial admission for a traumatic cervical spine fracture.

Table 2 Summary of patient factors and outcomes based on treatment groups

Number of patients	Overall (n=10938)	Rigid collar (n=8091)	Halo (n=1543)	Surgical fixation (n=1304)
Females (%)	53.5	55.0	50.9*	48.3*
Age Distribution (years)				
65–74 (%)	26.8	24.5	32.9*	32.3*
75–84 (%)	40.6	39.1	43.0*	45.8*
85–94 (%)	29.6	32.6	22.5*	21.3*
≥95 (%)	3.1	3.8	1.6*	0.6*
Polytrauma (%)	65.1	67.5	60.8*	55.5*†
Ground level fall (%)	39.25	40.01	38.04	35.97
Fall from height (%)	16.9	16.92	17.24	16.41
All other mechanisms (%)	43.85	43.07	44.72	47.62*
Tracheostomy (%)	5.4	3.09	6.03*	7.13*
Gastrostomy (%)	4.9	2.76	5.31*	6.52*
Dementia (%)	2.54	2.62	2.72	1.84
Complication during initial admission %	18.9	18.3	18.0	24.1*†
Mortality				
Overall (%)	50.3	51.4	52.0	41.5*†
Initial admission (%)	9.9	10.8	7.3*	6.2*
Initial admission+complication (%)	22.4	24.1	18.1	18.2
30 day (%)	14.4	16.2	11.2*	7.3*†
30-day+complication (%)	27.2	30.5	21.3*	16.9*
1 year (%)	28.3	30.2	26.2*	19.0*†
1 year+complication (%)	46.0	47.3	45.9	39.5

*Indicates p<0.05 when compared with rigid collar.
†Indicates p<0.05 when compared with halo.

intervention (OR 0.69 and OR 0.54, respectively) and female gender (OR 0.61, 95% CI 0.54 to 0.70). SRR divided into quartiles (Q) from 0 to 1 correlated with decreased odds of mortality when Q1 was compared with Q2, 3 and 4 (OR 0.18, OR 0.06 and OR 0.04, respectively). Higher SRR quartile portends a better chance of survival. Factors that did not have a significant impact on mortality during the initial admission (p>0.05) were dementia, mechanism of injury or race. Univariate logistic regressions for odds of mortality were performed for the same patient variables at 30 days and 1 year after injury; these findings are summarized in table 3.

Significant predictors of death based on multivariate logistic regression for the initial hospitalization included having a complication, advancing age, CCI of ≥2, and TBI. Patient factors that were significantly protective against mortality (p≤0.05) were surgical fixation, female gender, and higher SRR. Factors that did not have a significant impact on mortality (p>0.05) included race, halo, polytrauma, dementia, dysphagia, having a tracheostomy or gastrostomy performed, mechanism of injury, and admission to a designated trauma center (figure 2).

The multivariate logistic regression for the odds of death during the initial hospitalization, at 30 days and 1 year are summarized in figure 2. Asian race had a decreased odds of death at 30 days and 1 year compared with non-Hispanic white (OR 0.71, p=0.02; OR 0.67, p<0.001, respectively). Other race category had a decreased odds of death at 1 year (OR 0.62, p=0.01). Race was not a significant predictor of mortality at any other time points in the multivariate logistic regression analysis.

Dementia and dysphagia were not predictors of mortality at any time points in the multivariate logistic regression analysis.

Multivariate Cox regression for significant predictors of death during the entire study period included having a complication at the initial hospitalization (HR 1.35), CCI of 1 or ≥2 compared with 0 (HR 1.41 and OR 2.02, respectively), advancing age, dysphagia (HR 1.24), and TBI (HR 1.19). Patient variables that were significantly protective against death were having a surgical intervention (HR 0.75), initial admission to a designated trauma center (HR 0.93) female gender (HR 0.76), race compared with non-Hispanic white (Hispanic HR 0.88, Asian HR 0.71 and other HR 0.68). In addition, having a higher SRR quartile was protective against death, HR 0.37, HR 0.15 and HR 0.14 for Q2, Q3 and Q4 compared with Q1, respectively. Variables that did not have an impact on death were placement of a halo compared with rigid collar only, polytrauma, dementia, having a tracheostomy or gastrostomy performed and Black race compared with non-Hispanic white.

DISCUSSION

Elderly patients, aged 65 and above, suffering from cervical spine fractures have significantly increased morbidity and mortality compared with their younger injured counterparts.[11-13] Similarly, elderly patients suffering from hip fractures have high morbidity and mortality; however, this is improved by expeditious fixation and early mobilization.[14 15] One could surmise that the same principles apply to elderly patients suffering from cervical spine fractures where fixation and early mobilization may also improve outcomes. As the treatment of these fractures varies widely between institutions and even between individual surgeons at the same institution, it is important to continue to investigate this topic to better define criteria for different treatment modalities.

When considering life expectancy after admission for a cervical spine fraction, there are significant differences in mortality rates for patients with every decade increase in age (figure 1). In 2010 based on the 2013 National vital statistics, the 1-year mortality rate was 4% for patients aged 65–74, 10% for those aged 75–84% and 14% for those aged 85 or older.[16] In contrast, survival curves for this study population demonstrated 1-year mortality rates for patients aged 65–74 at 15%, aged 75–84 at 27%, aged 85–94 at 41% and above 95 years at 53%. Mortality rates for the elderly sustaining cervical spine fractures were substantially increased by 2–3 times compared with that of the general population, emphasizing the importance of studying predictors of mortality in these patients to improve outcomes. The increased mortality rates are similar to those published by Schoenfeld et al, in 2011.[8]

In 1995, Bednar et al, studied an aggressive protocol for surgical fixation of odontoid fractures with early mobilization; though this study is limited by small sample size, it showed a significant decrease in in-hospital mortality from 27% to 0%.[17] Our study also suggests that treatment modality is a potential predictor of outcomes, finding that patients managed with a halo had a similar mortality odds compared with rigid collar alone. Conversely, patients undergoing surgical fixation had a decreased odds of mortality by at least 35% at all time points after injury when compared with patients managed in a rigid collar. These results are similar to those reported by Schoenfeld et al, in 2011 with a lower 1-year mortality rate of 21% for elderly patients treated operatively compared with those treated with a halo or collar alone with mortality rates of 32% and 37%, respectively.[8] Our findings contribute to the body of evidence

Table 3 Univariate logistic regressions for predictors of death during the initial hospitalization, 30 days and 1 year after injury for patients with cervical spine fractures

	Index			30 days			1 year		
	OR	P values	95% CI	OR	P values	95% CI	OR	P values	95% CI
Complication	3.86	0.00	3.38 to 4.40	2.89	0.00	2.58 to 3.25	2.67	0.00	2.41 to 2.94
Intervention (referent: cervical collar)									
Halo	0.69	0.00	0.57 to 0.84	0.65	0.00	0.55 to 0.77	0.82	0.00	0.73 to 0.93
Surgery	0.54	0.00	0.43 to 0.69	0.41	0.00	0.33 to 0.51	0.54	0.00	0.47 to 0.63
Intervention (referent: no intervention)									
Tracheostomy	2.31	0.00	1.81 to 2.96	0.82	0.17	0.61 to 1.09	2.12	0.00	1.75 to 2.58
Gastrostomy	1.63	0.00	1.22 to 2.17	0.91	0.54	0.68 to 1.23	2.70	0.00	2.20 to 3.30
Age groups (referent: 65–74)									
75–84	1.73	0.00	1.43 to 2.08	2.11	0.00	1.78 to 2.49	2.07	0.00	1.83 to 2.34
85–94	2.65	0.00	2.20 to 3.19	3.88	0.00	3.28 to 4.59	3.92	0.00	3.47 to 4.44
>95	2.76	0.00	1.96 to 3.89	5.95	0.00	4.51 to 7.83	6.18	0.00	4.88 to 7.83
Female	0.61	0.00	0.54 to 0.70	0.72	0.00	0.65 to 0.81	0.74	0.00	0.69 to 0.81
Polytrauma	1.42	0.00	1.23 to 1.63	1.22	0.00	1.09 to 1.37	0.96	0.32	0.88 to 1.04
TBI	2.95	0.00	2.53 to 3.43	2.16	0.00	1.87 to 2.48	1.59	0.00	1.41 to 1.80
Falls (referent: all non-fall mechanisms)									
Fall from height	0.94	0.38	0.82 to 1.08	1.32	0.00	1.17 to 1.49	1.60	0.00	1.46 to 1.15
Same level fall	1.04	0.67	0.87 to 1.24	1.29	0.00	1.11 to 1.50	1.30	0.00	1.15 to 1.46
Traditional survival risk ratio (referent: 0–0.24)									
0.25–0.49	0.18	0.00	0.12 to 0.29	0.18	0.00	0.11 to 0.29	0.19	0.00	0.11 to 0.31
0.5–0.75	0.06	0.00	0.04 to 0.09	0.07	0.00	0.05 to 0.11	0.09	0.00	0.05 to 0.14
0.75–1	0.04	0.00	0.02 to 0.05	0.06	0.00	0.04 to 0.09	0.09	0.00	0.06 to 0.14
Comorbidities									
Dysphagia	1.30	0.03	1.02 to 1.65	1.53	0.00	1.26 to 1.87	1.78	0.00	1.52 to 2.09
Dementia	1.02	0.91	0.69 to 1.52	1.45	0.02	1.07 to 1.96	1.96	0.00	1.54 to 2.50
Obesity	0.64	0.07	0.39 to 1.04	0.63	0.03	0.42 to 0.95	0.65	0.01	0.48 to 0.88
Charlson Comorbidity Index (CCI)* (referent: 0)									
CCI=1	1.33	0.00	1.14 to 1.55	1.41	0.00	1.24 to 1.61	1.64	0.00	1.49 to 1.82
CCI≥2	2.07	0.00	1.79 to 2.41	2.36	0.00	2.08 to 2.69	2.91	0.00	2.63 to 3.23
Race (referent: white)									
Blacks	0.79	0.29	0.51 to 1.22	0.66	0.03	0.45 to 0.97	0.97	0.81	0.75 to 1.25
Hispanics	1.12	0.31	0.90 to 1.39	0.90	0.28	0.74 to 1.09	0.86	0.05	0.74 to 1.00
Asians	0.97	0.84	0.73 to 1.29	0.76	0.04	0.59 to 0.98	0.69	0.00	0.57 to 0.84
Indian/others	1.02	0.92	0.67 to 1.57	0.82	0.31	0.56 to 1.20	0.64	0.01	0.47 to 0.87
Trauma center	1.17	0.02	1.03 to 1.32	0.95	0.31	0.85 to 1.05	0.85	0.00	0.78 to 0.93

*CCI correlated 1 year risk of mortality: 0=8%, 1=25%, 2=48%, 3=59%.

suggesting that surgical fixation of cervical spine fractures is associated with a better outcome than management with a rigid collar or halo, even when accounting for patient age, comorbidities, and complications.

Any patient who had a complication during their initial admission had ≥3 times the odds of dying during the initial hospitalization compared with those who did not. The odds of dying remained significantly high at 30 days and 1 year after injury. The rate of having ≥1 complication at the initial admission was highest in patients undergoing surgical fixation at 24% compared with 18% for both the rigid collar and halo groups. Despite the increased rate of complications and associated mortality odds, conservatively managed patients still had a higher overall mortality. This again suggests that there is something protective about having surgical fixation performed.

Falls as a mechanism of injury compared with all other mechanisms (ie, motor vehicle accidents or assaults) were not

a significant predictor of mortality during the initial hospitalization; with 85% of patients leaving the hospital by the end of 2 weeks with a mean hospital stay of 9 days. However, at 30 days and 1 year after injury, falls were found to be a significant predictor of death. This could be interpreted as a sign of greater frailty in patients who fall, suggesting that although patients make it out of the hospital; they more often have other comorbid factors that contributed to their fall and ultimately their post discharge death. Dementia was included in the analysis for its known impact on frailty and potential as a predictor of mortality.[18] Dementia was not a predictor of death in our analysis, though this is likely due to under-reporting of this comorbidity in the database.

This study has several limitations. Large population-based administrative databases are not designed for research and lack a great deal of clinical granularity, as well as intention to treat allowing for significant selection bias to go undetected.
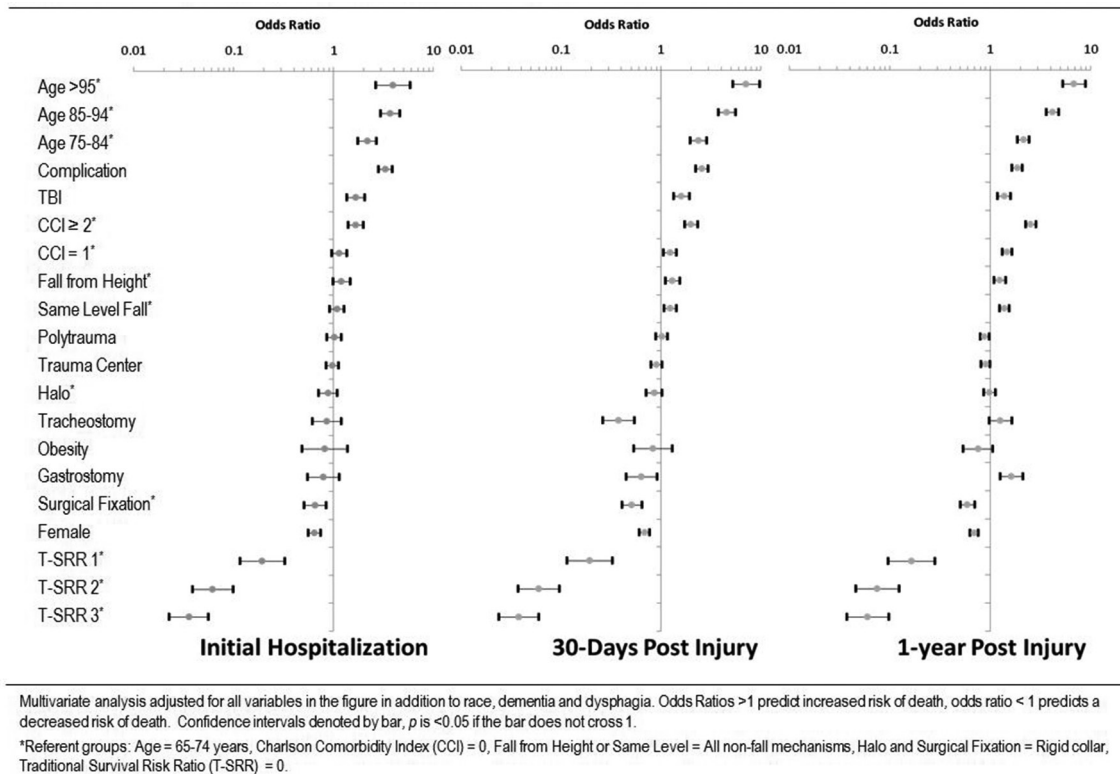
Figure 2 Multivariate logistic regression for adjusted predictors of death during the initial hospitalization, 30 days and 1 year after injury for patients with cervical spine fractures.

Conclusions drawn from the analysis of this type of study are primarily descriptive in nature. Importantly, our data is unable to describe the specific indications for the management chosen, or the type of surgical fixation performed. In addition, determination of frailty based on preinjury functional status cannot be analyzed because this information is not captured in the database, or is the patient mobility and activity level after injury available. Finally, there is also no way to calculate the extent of missing data, as absence of a particular code may indicate a true negative, the absence of testing, or failure of documentation. This potential for missing data points makes it possible that patients who underwent surgical fixation were mislabeled as cervical collar only if the operation was not reported. Though these limitations must be kept in mind, the true power of this database is the ability to follow a large group of patients over time to analyze mortality long after the initial admission. Although further clinical trials need to be done to address the questions regarding specific indications for surgical intervention, this type of investigation is important for identifying potential predictors of outcomes that smaller trials would be underpowered to find.

In summary, mortality rate after cervical spine fracture in the elderly is high. At 1 year, after the injury, more than one in four patients above the age of 75 will die, demonstrating a decreased life expectancy in this patient population. Surgical spine fixation is associated with a significant improvement in the odds of survival after cervical spine fracture. Future investigations should ideally focus on identifying optimal surgical indications and timing of surgical intervention.

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