

Pilot Study: Age As A factor in Time To Surgery For Traumatic Cervical Spine Fracture Patients

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Abstract

INTRODUCTION: Cervical spine fractures with or without spinal cord injury (SCI) disproportionately impact the elderly, who constitute an increasing percentage of the US population. Early surgical intervention is a safe, modifiable factor that enables early mobilization and subsequent reduction in complications and hospital length of stay. Surgical treatment of the elderly is complex, due to increased comorbidity factors and complications.

METHODS: In a pilot study from a Level 1 Trauma Center, we analyzed the number of patients treated with cervical spine fractures with or without SCI by age group (<65, 65-84, ≥85) and determined the influence of age on time-to-surgery and long-term mortality. Acute in-hospital mortality was calculated and long-term mortality within the study period (2003-2013) was determined from the National Death Index.

RESULTS: Data from patients (N=72) with cervical spine fractures treated surgically were analyzed, with nearly equal numbers under or over age 65. Although there was a trend of increasing time to surgery with increasing age, there was no statistical difference between the age groups ($p=0.7015$). The average time to surgery was less for patients with SCI than for all patients, and less for patients with than without central cord syndrome. The average time to surgery was longer for patients with vertebral fractures than for patients with SCI. There was no statistical difference for in-hospital or long-term mortality for patients with or without SCI or among the time-to-surgery groups. However, this is likely due to the low number of cases in this pilot study.

CONCLUSION: Data from this pilot study indicate an association between time to surgery and survival status of patients in any age or time-to-surgery groups examined. This analysis will enable a larger future prospective study and local quality control initiatives to collect additional data on factors influencing time-to-surgery in patients with cervical spine fractures.

Introduction

Traumatic spinal cord injury (SCI) is a devastating injury, with an incidence of approximately 17,700 cases in the United States annually [1]. Less is known about cervical spine fractures, but Passias and colleagues found a 5% incidence rate among all trauma discharges identified in the NIS database from 2005-2013 [2]. Over the past 3 decades, there has been an epidemiological shift in the age of patients who experience traumatic SCI, with patients over the age of 70 predicted to account for most new SCI cases by 2032 [3] [4]. Age of patients experiencing cervical fractures without SCI has steadily increased since 2005, as mechanism of injury has shifted from motor vehicle collisions (MVC) to falls [5]. Elderly patients often experience a different, lower-energy mechanism of injury as compared to younger patients; falls from standing account for more than 50% of cervical injuries in this age group [6]. Surgical treatment of the elderly is a complex issue, due to the increased prevalence of comorbid factors and complications that may impact surgical outcomes [3] [6].

Early surgical decompression of the spinal cord has been shown to be a safe, modifiable factor in the treatment of SCI that may minimize secondary effects and promote long-term function recovery [7] [8] [9] [10] [11]. The main treatment goal of cervical fractures associated with spinal cord injuries is the decompression of the nerve structures and restoring the stability of the spine [12]. From 2009 to 2012, there has been an increase in the decision to surgically intervene in acute spinal cord injuries, as compared to more conservative options like a halo vest [12]. A major goal of early surgery after cervical fracture for individuals with or without SCI is to allow for early mobilization, in an attempt to reduce the occurrence of complications, reduce hospital length of stay (LOS) and subsequent morbidity [8] [13] [12] and to facilitate quicker transitions to rehabilitation. In a study of 779 SCI patients with all levels of injury, McKinley and colleagues found that patients with SCI who underwent early surgery (<72 hours) had significantly shorter LOS and decreased occurrence of pneumonia and atelectasis [13].

Older age at the time of injury is associated with higher mortality rates in the acute and chronic stages after traumatic SCI [2]. Ahn and colleagues found that patients over the age of 70 experience longer times to surgery, which was attributed to a perceived lower urgency in obtaining diagnosis and therapeutic plans [3]. Older patients who experience longer times to surgery have substantially higher rates of in-hospital mortality, despite having less severe injuries [3]. In a study comparing mortality rates after SCI between younger and older (≥ 65) individuals, Furlan and colleagues found a significantly higher rate of mortality among the elderly throughout the first year after injury [4]. They attributed this increased mortality rate to pre-existing medical co-morbidities observed in the elderly cohort [4]. Similarly, Golob and colleagues demonstrated high mortality rates and unfavorable disposition outcomes for patients who were at least 65 years old with isolated cervical vertebral fractures [6].

To begin to understand factors that contribute to variance in time-to-surgery in patients with cervical spine fractures, here we considered the impact of age (<65, 65-84, ≥ 85) in a pilot analysis of sequential cases with and without SCI, treated over a ten year period at a New York State American College of Surgeons (ACS)-verified Level I Trauma Center. Data was analyzed with respect to acute in-hospital and long-term (within the study period) mortality.

Methods

Study Population This retrospective chart review study was approved by the local Institutional Review Board. The institutional trauma registry (Trauma One, Lancet Technologies) was used to identify patients greater than 18 years of age admitted from Jan 1, 2003 to Dec. 31, 2013 with a primary diagnosis code of ICD-9 codes 806 or 952, corresponding to acute spinal cord injury. Patients presenting with fracture of the vertebral column without SCI, ICD-9 codes 805 or 805.1, were included as a control group. As our purpose was to study patients with isolated SCI or spine fractures, all patients with an Abbreviated Injury Score (AIS) greater than 2 for any body region other than spine was excluded.

Data Collection Data was abstracted from the institutional trauma registry and from patient medical records. The following data were examined: age, gender, race, SCI status, history of comorbidity,

admission time, surgical status, time from admission to surgery and long-term (after acute hospital discharge but within the study period) mortality. Survival after acute hospitalization during the remainder of the study period was determined by data obtained from the US National Death Index (NDI), part of the National Center for Health Statistics. Patient records were analyzed in three groups according to their age at time of admission: <65, 65-84, and ≥85. Within the three age groups, records were then analyzed in three time-to-surgery groups: >24, 24-72, and >72 hours, consistent with previous studies. Additionally, patient records were separated into two groups: cervical fracture without SCI and cervical fracture with SCI. Within the cervical fracture with SCI group, records were then analyzed in two groups: SCI with central cord syndrome (CCS) and SCI without CCS. Other analyses of some of this data without analysis of time to surgery was previously published [14].

Results

A total of 632 patient charts were reviewed in this pilot study. Of those, 544 did not receive surgery and were therefore excluded from the remaining analysis. Of the 89 patients who did receive surgery, 72 charts were available for review (Figure 1). Patient demographics are described in Table 1. Of the 72 eligible patients, 40% were female, and 70% were White. The average age of patients was 60 ± 19 years old (mean ±SD) and the age range was 19-95 years. Analysis groups are described in Table 2. There were almost equal numbers of persons older or younger than age 65 and a minority older than 85: N= 35 (5.54% of total group) <65 v. N=30 (4.75%) 65-84 v. N= 7 (1.11%) ≥85.

Table 1. Participant Demographics (N=72)

Data	Unit Indicated
Age, years (Mean±SD, Range)	60±19 (19-95)
Gender	
Female, N (%)	29 (40%)
Male, N (%)	43 (60%)
Diagnosis	
SCI	36 (50%)
Cervical fracture	36 (50%)
Survival status	
Dead	22 (30.5%)
Alive	50 (69.5%)
Charlson Comorbidity Score, by age group (Mean±SD, range)	
≤65	0±1 (0-3)
65-84	0.93± 1.29 (0-6)
≥85	1±1.25 (0-3)

Table 2. Analysis Groups (N=72)

Group	N
Time to surgery, by age group	
≤65	35
65–84	30
≥85	7
Time to surgery, by time group	
≤24 hours	18
>24≤72 hours	20
>72 hours	34
Time to surgery, by diagnosis	
SCI	36
Vertebral Fracture	36

Time to Surgery for All Patients

The average time to surgery for all patients (N=72) was 85.2 ± 72.99 hours (mean \pm SD). The average time to surgery by group is shown in Table 3. Nearly the majority of all patients had a time to surgery of greater than 72h (N=34, 47.2%), while almost an equal number of patients had a time to surgery of ≤ 24 or >24-72 hours, respectively (N=18, 25%, N=20, 27.8%). The distribution of average time to surgery by age group is shown in Table 3. Although there was a trend of increasing time to surgery with increasing age, there was no statistical difference in the average time to surgery among the three age groups ($p=0.7015$).

Table 3. Mean time to surgery

<u>Data</u>	<u>Unit Indicated</u>
Mean time to surgery, hours, (Mean±SD, Range)	85.2±72.99 (2.45–376.6)
Time to surgery, hours, by age group (Mean±SD, Range)	
≤65	81.04±73.06 (2.45–291.28)
65–84	97.01±82.30 (3.13–376.60)
≥85	82.6±65.22 (4.1–167.95)
Time to surgery, hours, by time group (Mean±SD, Range)	
≤24 hours	11.97±7.15 (2.45–23.83)
>24≤72 hours	48.23±14.42 (24.37–69.87)
>72 hours	151.32±65.76 (73.38–376.6)
Time to surgery, hours, SCI (Mean±SD, Range)	
≤65	74.49±72.2 (4.85–291.28)
65–84	90.24± 98.45 (3.13–376.6)
≥85	0±0 (no participants)
Time to surgery, hours, SCI & CCS	
SCI NO CCS	59.34± 11.91 (3.13–216.38)
CCS	120.7±31.88 (5.95–291.28)
Time to surgery, hours, Vertebral Fracture (Mean±SD, Range)	
≤65	89.76±73.28 (2.45–235.17)
65–84	111.19± 62.15 (32.48–219.02)
≥85	102.72±73.84 (4.10–192.87)

Time to Surgery for Patients with Cervical Fractures with SCI

Half of the patients included in this analysis had a traumatic SCI. The distribution of patients with SCI (N=36) who had surgery by age group was: <65 years old, N=20 and 65-84 years old, N=16. There were no patients in the >85 years old group with SCI. Within each age group, the average time to surgery for patients with SCI was shorter than the average time for all patients: less than 65 years old, 74.49±72.2 hours, 65-84 years old, 90.24± 98.45 hours (mean ± SD) (Table 3). Many (41.6%) patients with SCI were diagnosed with central cord syndrome (CCS), the most common incomplete SCI syndrome (Ahuja et al 2017). There was a significant difference in time to surgery between SCI patients with or without central cord syndrome (P=0.0389) (Table 3). The mean time to surgery was significantly shorter for patients with SCI with CCS than for SCI without CCS, (59.34± 11.91 vs. 120.7± 31.88 hours, mean± SEM) respectively).

The most common surgical procedures for patients with SCI were: cervical fusion of the anterior column via anterior technique (ICD9 81.02), cervical fusion of the posterior column via posterior technique (ICD9 81.03), exploration and decompression of the spinal canal (ICD9 03.09) and atlas-axis spinal fusion (ICD9 81.01), which were performed in all age groups. Only patients in the 65-84 age group had surgery characterized by ICD9 code 81.63, corresponding to “fusion of re-fusion of 4-8 vertebrae.”

Time to Surgery for Patients with Cervical Fractures without SCI

Half of the patients included in this analysis had a cervical vertebral fracture without a SCI. The average time to surgery for patients with a vertebral fracture was longer than those who sustained a SCI: <65 years old (N=15) 89.76±73.28 hours, 65-84 years old (N=14) 111.19± 62.15 hours, ≥85 years old (N=7) 82.6±65.22 hours, (mean ± SD) (Table 3). The most common surgical procedure for patients with vertebral fractures were: cervical fusion of the anterior column via anterior and posterior technique, respectively (ICD9 81.02, ICD9 81.03), fusion or re-fusion of 2-3 or 4-8 vertebrae, (ICD9 81.62, ICD9 81.63), excision of intervertebral disc (ICD9 80.51) and atlas-axis spinal fusion (ICD9 81.01), which were performed in all age groups.

Of the patients included in this analysis who received surgery (N=72), 30.6% died after acute hospitalization, but within the study period (2003-2013, with a mean follow up period of 63 months), as compared to 36.83% of the patients who did not receive surgery (N=544). For patients with cervical fractures who received surgery, there was no statistical difference for in-hospital mortality between patients with or without SCI (P=0.6485, P=0.4438, respectively). Similarly, there was no statistical difference between these groups in long-term mortality (after hospital discharge but during the study period) (P=0.4438). In fact, there was no association between time to surgery and survival status of patients in any of the age groups examined. As expected, months of follow up decreased with increasing age (Table 4). No statistically significant difference in long-term mortality was found among the time to surgery groups. When age was evaluated as a continuous variable, there was no statistical difference in mortality between patients who did or did not receive surgery (P=0.241).

Table 4. Follow up time and Length of Stay

<u>Data</u>	<u>Unit Indicated</u>
Time of follow up, months, by age group (Mean±SD, range)	
≤65	48±33.37 (0-131)
65-84	34±30.27 (0-108)
≥85	28.57±22.96 (0-59)
Length of hospital stay, days, by time group (Mean±SD, range)	
<24	22.39±22.14 (4-95)
24-72	16.25±10.40 (6-52)
>72	20.82±15.93 (7-86)

The number of comorbidities within each age group was calculated using the Charlson Comorbidity Index (CCI) and was 0 ± 1 (≤ 65), 0.93 ± 1.29 (65-84), 1 ± 1.25 (≥ 85). Somewhat surprisingly, there was no statistically significant difference in the number or severity of comorbidities among the age groups, ($P=0.1483$, Table 1). All age groups had histories of cardiovascular complications, demonstrated by ICD9 codes 412 Old Myocardial Infarction, 427.31 Atrial Fibrillation and 414.01 Coronary Atherosclerosis of Native Coronary Vessel. As expected, only the two oldest age groups had recorded long-term use of anti-coagulant medications (ICD9 V58.61). Unexpectedly, only the two youngest age groups had a documented history of pneumonia (ICD9 486). Alcohol abuse (ICD9 305) was recorded as present only in the youngest group, while tobacco use disorder (ICD9 305.1) was recorded as present in both the <65 and 65-84 age groups.

The prevalence of comorbidities was greater in the time to surgery group >72 hour than in the earlier (<24 and 24-72 hour) time to surgery groups. Long-term use of anti-coagulants (ICD V58.61), old myocardial infarction (ICD9 412) and pneumonia (ICD9 486) were unique to the >72 and 24-72 hour groups. All time to surgery groups included patients with atrial fibrillation (ICD 427.31), unspecified essential hypertension (ICD9 401.9) and diabetes mellitus without complication (ICD9 250). There was no statistically significant difference in hospital length of stay between time to surgery groups ($P=0.4926$, Table 4). There was a trend toward higher ISS scores among patients in the <24 hour group, which may contribute to longer hospital lengths of stay, despite quicker surgical times.

Discussion

Whether there is an optimal time to surgery for patients with cervical spine injuries is still unclear, with time to surgery categorized as ultra-early (<12 hours), early (less than 24 hours or 24-72 hours) or late (>72 hours) [13] [15]. Shorter times to surgery after cervical vertebral fracture and SCI allow for earlier patient mobilization, which may reduce the rate of complications, [8] which have been shown to lead to longer LOS and higher rates of in-hospital mortality [16]. Aarabi and colleagues concluded that it was not

time to surgery, but intramedullary lesion length, that most influenced neurological recovery after surgical decompression [15].

Surgery (decompression and other) after SCI is thought to prevent further neurological deterioration, accelerate the rehabilitation process and help prevent complications associated with prolonged immobilization [17]. Despite time to surgery being an intense topic of clinical interest, several studies have noted that time to surgery varies widely and patients with later times to surgery tend to be older and have neurologically incomplete injuries [13]. In a large retrospective study of patients with cervical SCI (N=2636), the majority (55.1%) of patients within an age range of 18-80+ did not undergo surgery within 24 hours [18]. Dvorak and colleagues demonstrated a mean time to surgery of 60 hours, with only 40% patients of adults receiving surgical intervention within 24 hours [11]. Similarly, in a retrospective cohort study of 431 patients with SCI, only 20% of patients received surgical intervention within 24 hours, and over 25% received surgical intervention after 72 hours [8].

In this pilot study, we began to examine the question of factors that influence time to surgery and mortality in a small number (N=72) cases of patients with cervical spine fractures and found that nearly half (47.2%) of patients included in this analysis had a time to surgery that would be considered "late," >72 hours, with a mean time to surgery of 85 hours. Of note, we often needed to examine individual patient medical records in addition to data collected in the trauma registry, identifying the need for a quality control initiative to increase more structured registry data collection relevant to time-to-surgery. While the study was under-powered to draw generalizable conclusions, here we share this analysis of pilot data to advance the discussion of issues that may impact data gathering on and care of geriatric trauma patients at other level 1 trauma centers.

Time to surgery may vary within and affect subpopulations differently. For example, Ahn and colleagues found that an age threshold of 65 years affected surgical decisions, with older individuals experiencing more time to surgery [3]. Burke and colleagues found that for patients with cervical SCI, ultra-early surgery was associated with the best American Spinal Injury Association Impairment Scale (AIS) grade conversion rates [19]. Du and colleagues found that time to surgery influenced neurological recovery differently according to the AOSpine subaxial cervical SCI classification, but mortality was not statistically different between early and late surgery groups [20]. Here, we explored if there was a correlation between age and time to surgery in patients with cervical fractures analyzed by age groups of <65, 65-84, and \geq 85 years old. Although there was a trend of increasing time to surgery with increasing age, we found no statistically significant difference between the times to surgery among the age groups (P=0.7015). Although nearly the majority of cases reviewed in this study had a time to surgery of >72 hours, we did not find a significant correlation with long-term mortality within the study period. We also did not find a significant difference in CCI score or LOS among age groups. This may be because of the small (N=72) number of patients with surgery included in this study. Neurological recovery was not included in this study due to a lack of data.

The time to surgery for patients with SCI without CCS was significantly shorter than those with SCI with central cord syndrome (CSS). CSS is characterized by increased weakness of the upper versus lower extremities, variable sensory loss and less severe bladder, bowel and sexual dysfunction, and represents the most common type of incomplete SCI [21]. Although CSS patients experience dramatic neurological improvement and have a favorable recovery pattern compared with other motor complete tetraplegics [22], there is still a need for timely surgical intervention to address underlying degeneration, manage secondary injury cascades and decrease the risk of future events [11] [21]. Traditionally CCS patients have been managed more conservatively, but with improvements in surgical techniques, most cases are now treated surgically, with demonstrated neurological improvements when completed within 24 hours [18] [21]. In a group of 126 CCS patients, Stevens and colleagues found that nearly 40% of patients received surgical intervention after the recommended period of 24 hours, and over 10% received surgery on a second hospital admission [23]. Yamazaki et al. demonstrated significant overall health outcomes for TCSS patients who received surgery within 2 weeks of injury [24]. These initial pilot data support the notion that there may be a decreased urgency for surgical initiation in patients with CCS as compared to patients with SCI, with all patients receiving surgery within one week of injury. In the future we may also examine how surgical rates and time-to-surgery vary with respect to mortality in patients with spinal cord ischemia, stenosis and other forms of non-traumatic SCI.

There are many limitations to this pilot study, most notably the low number of cases that fit inclusion/exclusion criteria that underwent surgery after cervical fracture. As noted above, we also experienced a frequent need to consult individual medical records in addition to the Trauma Registry, indicating that a future quality control initiative should include additional structured data entered prospectively in the Trauma Registry that better facilitate identification of factors contributing to variance in time to surgery. These factors may include indicators of infection susceptibility and/or systemic inflammatory responses such as CBC and CRP levels, as well as others. Future studies with additional data gathered prospectively will enable a larger and more detailed analysis of factors influencing time to surgery and mortality in patients with cervical spine fractures.

Declarations

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: The authors declare that they have no conflict of interest.

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Ethical approval: This retrospective study was performed with permission of and in accordance with the local Institutional Review Board.

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Figures

Figure 1. Consort Diagram of Study Population

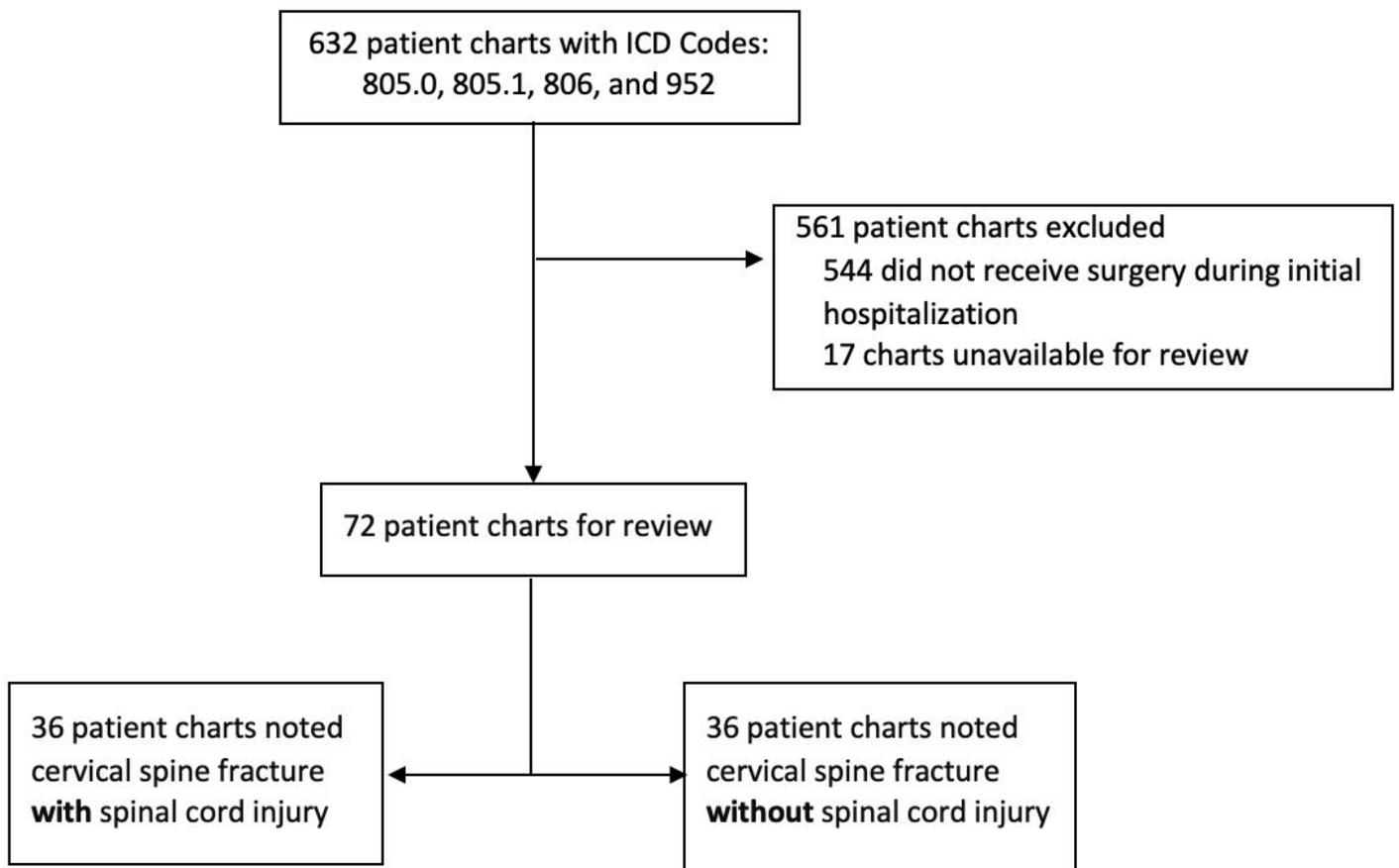


Figure 1

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