Acute Outcomes of Cervical Spine Injuries in the Elderly: Atlantaxial vs Subaxial Injuries

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Abstract

Background/Objective: Recent studies have reported on the outcomes of spinal cord injuries in the elderly. Our aim was to identify acute survival differences between elderly patients with atlantoaxial injuries relative to subaxial injuries at our institution and to determine whether operative treatment is associated with improved survival rates in either population.

Study Design: Retrospective database review of all traumatic cervical spine injuries in patients at least 65 years of age at a single tertiary care center.

Methods: A total of 193 consecutive patients at least 65 years of age treated at a single tertiary care center over a 12-year period were identified. Initial hospitalization records were reviewed. Patients were divided by anatomic level of injury: atlantoaxial (C1 or C2) and subaxial (C3 or below). Demographics, mechanism, and mortality rates were compared. Each group was further divided by treatment (operative or nonoperative), and inpatient survival rates were compared.

Results: Statistically similar survival rates were observed among patients with atlantoaxial and subaxial injuries ($P = 0.10$). Patients with nonoperatively treated subaxial injuries died at significantly higher rates than did their operatively treated peers ($P < 0.05$).

Conclusions: In this large comprehensive series of elderly patients with cervical spine injuries, survival rates were comparable regardless of anatomic level of injury. The operative treatment of subaxial injuries was associated with an improved acute survival rate vs nonoperative management. Further prospective study is needed to better assess this relationship.

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Key Words: Spinal cord injuries; Cervical spine trauma; Subaxial; Atlantoaxial; Spine surgery; Elderly; Mortality; Outcomes

INTRODUCTION

A recent study at our institution examining 12 years of operatively treated cervical spine injuries at a single tertiary care center in patients at least 65 years of age found acute postoperative mortality and complication rates to be substantially improved over prior published rates (1). Among elderly patients with surgically treated cervical injuries, 87.8% survived their initial hospitalizations (1).

A subsequent analysis found statistically comparable survival rates after the addition of all nonoperatively treated elderly patients with cervical injuries over the

same time period (2). The overall short-term survival of our composite population was determined to be 86% (2). Acknowledging that certain injury types may lend themselves to either operative or nonoperative management, the parity observed in survival rates between the operatively and nonoperatively treated patients was significant in that it contradicted the findings of at least one recent series that concluded that more conservative management modalities (eg, halo vest) may themselves contribute to a substantially increased risk of death in the elderly patient population (3).

The discordant findings of our series relative to others inspired further study. Recognizing that a very large number of patients would be needed to perform a direct comparison of operative vs nonoperative treatment

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Table 1. Patient Characteristics

	Atlanto-axial	Subaxial	No. Patients Overall
Total	75	118	193
Male	43	78	121
Female	32	40	72
Treatment			
Operative	9	65	74
Nonoperative	66	53	119
Neurologically intact	52	39	91
Neurologic deficit	23	79	102
Complete	6	27	33
Incomplete	17	52	69

outcomes for each specific injury type, this analysis sought to further clarify the debate by stratifying patients by level. The primary objective was to stratify our population of “all comers” at least 65 years of age with a variety of cervical spine injuries by level of injury to determine whether treatment method influenced mortality rate when more cephalad or more caudad injuries were specifically examined.

We reviewed all patients with traumatic cervical spine injuries, including those with fractures alone, instability (eg, subluxation, dislocation) with or without associated fracture, cervical spinal cord injuries (SCIs) and neurologic deficits with or without fracture (eg, central cord syndrome), and those with evidence of cord injury noted on imaging even in the absence of neurologic signs (eg, cord contusions). Secondary objectives included examination of the sex distribution, injury mechanisms, and injury types common to elderly patients with atlantoaxial or subaxial injuries.

METHODS

Institutional Review Board approval was obtained for all procedures in this study. A complete database review was performed of all traumatic cervical spine injuries treated at the Midwest Regional Spinal Cord Injury Care System at Northwestern University/Northwestern Memorial Hospital in Chicago over a 12-year period; 1,073 consecutive patients were identified, and the records of their initial hospitalizations were reviewed.

Complete prospectively collected data were available for 704 patients in an electronic database. For 369 patients for whom prospective data were unavailable, a thorough retrospective chart review was undertaken. Each review consisted of an examination of emergency room records, radiographic studies, daily progress notes, procedure reports (where applicable), and hospital discharge summary reports to ensure completeness.

Table 2. Injury Mechanisms

Mechanism	Atlantoaxial	Subaxial
Fall	37/75 = 49%	96/118 = 81%
Motor vehicle collision	28/75 = 37%	13/118 = 11%
Gunshot wound	0	1/118 = 1%
Non-handgun violence	0	0
Other	10/75 = 14%	8/118 = 7%

The acute postinjury period was defined as the duration of the initial hospitalization after injury. This period ranged from 1 to 159 days, with a mean length of stay of 19 days. All patients were treated by a multidisciplinary team and in accordance with the National Acute Spinal Cord Injury Study steroid protocols. From our prospective database and retrospective chart reviews, the following information was extracted for each patient: age, sex, injury mechanism, presenting neurologic status, a neurologic level for patients with deficits, pre-existing comorbidities, anatomic levels of injury, injury types, survival, and major complications.

A total of 193 patients at least 65 years of age were identified. Patients were divided into 2 groups by injury level: atlantoaxial (C1 or C2) and subaxial (C3 or below) (Table 1). Eleven patients with injuries at both the atlantoaxial and subaxial levels were classified by the most cephalad level of involvement. All calculations for statistical significance were repeated with the exclusion of these 11 patients to ensure that all observed differences were real.

Characteristics of each group were compared using the χ^2 method (Table 1). Statements of statistical significance were made at the $\alpha < 0.05$ level, except where noted. The Bonferroni modification was applied for multiple comparisons, and the Yates correction was used where expected frequencies were less than 5.

RESULTS

The total study population consisted of 121 men and 72 women. No significant difference existed between the sex distributions of the atlantoaxial and subaxial patient populations. The majority of injuries in both populations were caused by falls (Table 2). Patients with injuries to the lower cervical spine were significantly more likely to have fallen than those with more cephalad injuries ($P < 0.001$). Higher energy mechanisms were responsible for a significantly greater proportion of C1 and C2 injuries ($P < 0.001$). Exclusion of the 11 patients with combined injuries from the atlantoaxial group did not alter these findings.

Of 193 patients, 102 sustained neurologic injury, and 91 were intact; 23 patients with deficits on presentation had sustained atlantoaxial injuries, whereas 79 had

Table 3. Mortality Data

	Atlantoaxial	Subaxial	No./Total Overall
Overall mortality rate	6/75 (8%)	21/118 (18%)	27/193 (14%)
Neurologically intact	1/43 (2.3%)	3/48 (6.3%)	4/91 (4.4%)
With deficit	5/23 (22%)	18/79 (23%)	23/102 (23%)
Complete	2/6 (33%)	7/27 (26%)	9/33 (27%)
Incomplete	3/17 (18%)	11/52 (21%)	14/69 (20%)
Treatment			
Operative	0/9 (0%)	6/65 (9.2%)	9/74 (12%)
Nonoperative	6/66 (9.1%)	21/53 (40%)	18/119 (15%)

sustained subaxial injuries (Table 2). Elderly patients with more proximal injuries were significantly less likely to have sustained neurologic injuries than those with subaxial injuries. Exclusion of the combined injury population from the atlantoaxial group did not alter this finding.

The overall acute mortality rate was 14% for all patients at least 65 years of age with cervical spine injuries presenting to our tertiary care center over a 12-year period. Acute mortality for elderly patients with atlantoaxial injuries was 8.0% and for those with subaxial injuries was 18%. This difference was not statistically significant. Details are shown in Table 3. One death occurred among the 11 patients with combined injuries. Exclusion of these patients resulted in an atlantoaxial mortality rate of 7.8%. Again, no statistically significant difference in acute mortality was observed relative to the subaxially injured population.

Statistically similar survival rates were observed between elderly patients with atlantoaxial injuries and those with subaxial injuries for all presenting neurologic status types. No significant difference was observed in survival rates between those patients with C1 and C2 injuries treated operatively relative to those treated nonoperatively. Exclusion of the 11 patients with combined injuries did not alter this finding. However, patients in the subaxial group treated nonoperatively died at a significantly greater rate ($P < 0.001$) than did their operatively treated peers.

DISCUSSION

The 193 elderly patients with cervical injuries reviewed in this study comprise one of the largest databases published to date. The inclusion of a comprehensive set of cervical injuries (ie, not only fractures or SCIs) limited the direct comparison of some results with existing literature. In the following discussion, areas where population differences may have introduced variability are identified.

The atlantoaxial injury rate of 38.9% among the elderly in our series is somewhat lower than in other reports (3–5) and is likely a consequence of the inclusion of nonfracture injuries, which tend to occur in the mid- to

lower cervical spine (6). It has been consistently found that older individuals who sustain fractures of the cervical spine are significantly more likely to injure the first 2 cervical vertebrae than are younger adults (3–5).

Even among the elderly, the propensity for proximal involvement continues to increase with age. In a study population in which 64% of subjects had sustained atlantoaxial fractures, Lomoschitz et al (7) found the old elderly (> 75 years) to be significantly more likely to injure the upper cervical spine than the young elderly (65–75 years), regardless of mechanism. The authors postulated that progressive subaxial spondylosis and stiffness with aging predisposes the mobile proximal segments to injury.

Injury Mechanisms

A subgroup analysis of the 75 elderly patients with atlantoaxial injuries yielded results in agreement with existing literature (8–10). With respect to sex and mechanism, this subgroup of patients was statistically similar to the elderly population as a whole. Interestingly, motor vehicle collision was responsible for a significantly greater number of injuries among patients with more proximal injuries. We were surprised by this finding and postulated that the subaxially injured patients may have been significantly older than their atlantoaxial counterparts and, consequently, predisposed to injury by lower-energy mechanisms. No significant difference in age was found, however, between the 2 patient populations.

Overall Acute Mortality

No statistical difference in mortality rates among patients at least 65 years of age with atlantoaxial injuries was found relative to those with subaxial injuries. With 6 deaths among the elderly patients with atlantoaxial injuries, the acute mortality rate of 8.0% in this population at our center compares favorably with that of other series. Reported mortality rates of similar injuries in the elderly range from 7.3% to 34.8% (8–11).

Presenting Neurologic Status

Of 75 patients with atlantoaxial injuries, 23 (31%) had neurologic deficits on presentation. Although this rate of

Table 4. Characteristics of Common Atlantoaxial Injuries in the Elderly

Injury	No.	Male	Female	Falls	Auto	Died
Type 2 odontoid fracture	18	8	10	78%	17%	5
Hangman's fracture	11	6	5	73%	27%	0
Type 3 odontoid fracture	9	4	5	78%	22%	1
Jefferson fracture	6	4	2	67%	17%	1
Posterior arch fracture	6	2	4	83%	0%	0

neurologic injury is greater than in other series (8–10), again we suspect that the inclusion of nonfracture injuries limits the comparison of our population to that of fracture-only studies. Prior publications have also emphasized the lower rate of neurologic injury among elderly patients with odontoid fractures relative to subaxial fractures (8–10). We believe ours to be the first large series to show a similar “neurologic advantage” to a combined pool of C1 and C2 injuries.

Effect of Operative Treatment

A recently completed analysis at our tertiary care institution showed that when all cervical injuries in patients at least 65 years of age were considered together, the overall nonoperative mortality rate was statistically equivalent to that of operative treatment (2). This finding contradicted the conclusions of a recent publication, which had suggested that the nonoperative treatment modality (eg, halo vest) may itself be a major contributor to increased mortality rates with nonoperative treatment in an elderly population (3).

Recognizing that a very large number of patients would be needed to perform a direct comparison of operative and nonoperative treatment outcomes for each specific injury type, this analysis sought to further clarify the debate by stratifying patients by level. For a combined pool of C1 and C2 injuries, acute mortality rates were found to be comparable with operative and nonoperative treatment. That is, the nonoperative treatment of 66 elderly patients with C1 and C2 injuries was not observed to significantly increase their acute mortality, substantiating the earlier findings detailed above (2).

In contrast, nonoperatively treated elderly patients with subaxial injuries died at a significantly higher rate

than their operatively treated peers. As a retrospective study with multiple potential confounding factors, our analysis admittedly has limitations. Nonetheless, for this subgroup of elderly patients, it seems that nonoperative treatment may potentially contribute to an observed increased mortality, in corroboration of the findings of Majercik et al (3).

For patients treated nonoperatively, the modality used (eg, halo vest, type of cervical orthosis) was left to the discretion of the admitting surgeon and the multidisciplinary team. Limitations of our database and patient numbers in each group precluded a statistical analysis of survival by specific method of nonoperative treatment.

Another valid criticism of this series is the short-term follow-up, limited by the data available within the database and retrospective chart review. Several authors have noted that, in an elderly population with spine injuries, the in-hospital mortality may significantly underestimate the overall injury-related mortality (5,12). Certainly, surgical decision-making at the time of injury may have been influenced by the perceived ability of the patient to tolerate a surgical procedure. Surgical survival rates may have consequently been confounded by the presence of such a selection bias. A retrospective study cannot entirely address or identify the extent to which the data may have been influenced in this manner. A well-designed prospective effort would be needed to address this issue.

Injury-Specific Data for the Most Common Injury Types

Most publications today that examine C1 and C2 injuries in the elderly focus on the optimal management of specific fracture types. As the debate continues, much has

Table 5. Characteristics of Common Subaxial Cervical Spine Injuries in the Elderly

Injury	No.	Male	Female	Falls	Auto	Died
Cord contusion without fracture	11	10	1	73%	27%	1
Unilateral subluxation	11	10	1	73%	9%	5
Ant wedge compression fracture	11	2	9	36%	18%	0
Unilateral facet fracture	7	6	1	43%	57%	1
Unilateral lamina fracture	7	7	0	14%	43%	1

been written on the relative merits of operative vs nonoperative management (3,8). Less is known about the association of specific atlantoaxial injury types with sex, mechanism of injury, and mortality rates.

Those atlantoaxial and subaxial injuries noted to occur most frequently in the elderly in this series at a single tertiary care center are noted in Tables 4 and 5. As in prior publications, C2 was the most commonly injured level, and odontoid fractures were the most common injury overall (3,4,7,9). Unique to this publication are the demographic and mortality data for each listed injury type. Each injury type is noted to have a unique sex distribution, corresponding mechanism, and mortality rate. Because only 13% of the atlantoaxial injuries in patients at least 65 years of age were treated operatively, no treatment-based comparisons were made.

CONCLUSION

The acute mortality rate for elderly patients with atlantoaxial injuries was comparable with that of a similarly aged population with subaxial injuries. Nonoperatively treated elderly patients with subaxial injuries died at a significantly higher rate than their operatively treated peers. Unique to this study are the demographic and mortality data for each listed cervical spine injury. Each specific injury type is noted to have a unique sex distribution, corresponding mechanism, and mortality rate.

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