Value of aggressive surgical and intensive care unit in elderly patients with traumatic spinal cord injury

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OBJECTIVE The elderly are a growing subpopulation within traumatic spinal cord injury (SCI) patients. Studies have reported high morbidity and mortality rates in elderly patients who undergo surgery for SCI. In this study, the authors compare the perioperative outcomes of surgically managed elderly SCI patients with those of a younger cohort and those reported in the literature.

METHODS Data on a consecutive series of adult traumatic SCI patients surgically managed at a single institution in the period from 2007 to 2017 were retrospectively reviewed. The cohort was divided into two groups based on age: younger than 70 years and 70 years or older. Assessed outcomes included complications, in-hospital mortality, intensive care unit (ICU) stay, hospital length of stay (LOS), disposition, and neurological status.

RESULTS A total of 106 patients were included in the study: 83 young and 23 elderly. The two groups were similar in terms of imaging features (cord hemorrhage and fracture), operative technique, and American Spinal Injury Association Impairment Scale (AIS) grade. The elderly had a significantly higher proportion of cervical SCIs (95.7% vs 71.1%, $p = 0.047$). There were no significant differences between the young and the elderly in terms of the ICU stay (13.1 vs 13.3 days, respectively, $p = 0.948$) and hospital LOS (23.3 vs 21.7 days, $p = 0.793$). Elderly patients experienced significantly higher complication (73.9% vs 43.4%, $p = 0.010$) and mortality (13.0% vs 1.2%, $p = 0.008$) rates; in other words, the elderly patients had 1.7 times and 10.8 times the rate of complications and mortality, respectively, than the younger patients. No elderly patients were discharged home (0.0% vs 18.1%, $p = 0.029$). Discharge AIS grade and AIS grade change were similar between the groups.

CONCLUSIONS Elderly patients had higher complication and mortality rates than those in younger patients and were less likely to be discharged home. However, it does seem that mortality rates have improved compared to those in prior historical reports.

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KEYWORDS age; complications; elderly; morbidity; mortality; spinal cord injury; trauma

TRAUMATIC spinal cord injury (SCI) is a major cause of morbidity and mortality in the United States. Its national incidence is 12,000–15,000 cases per year, approximately 40–50 persons per million.^{20,22,26} SCI is associated with significant disability, a reduction in quality of life, and decreased life expectancy.^{11,20} The 25-year survival is low and dependent on neurological status, ranging from 70% (American Spinal Injury Association grade

D) to 23% (ventilator dependent).⁴¹ At the same time, when SCI patients are treated with appropriate urgency, protocol-driven intensive care unit (ICU) management, and surgical intervention, they can obtain acceptable outcomes, especially those who present with mild neurological deficits.^{29,32} Even patients presenting with functionally complete SCI can benefit from early surgical intervention.⁵ Prompt operative management of SCI has been shown to

ABBREVIATIONS AIS = American Spinal Injury Association Impairment Scale; AKI = acute kidney injury; BASIC = Brain and Spinal Injury Center; DVT = deep vein thrombosis; GCS = Glasgow Coma Scale; ICU = intensive care unit; LOS = length of stay; MAP = mean arterial pressure; PE = pulmonary embolus; SCI = spinal cord injury; SNF = subacute nursing facility; TBI = traumatic brain injury; UTI = urinary tract infection; VCR = vertebral column resection.

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be associated with a lower mortality rate, even after adjusting for differences in age, sex, and comorbidities; however, it can also be associated with higher rates of complications than nonoperative management.^{6,14,21,35,37,42}

Elderly patients are inherently more susceptible to SCI because of a high fall risk and osteoporotic bone. Over the past decade, there has been a shift in the mean age at SCI from 26 years old to 38 years old,⁴ resulting in an increasingly large proportion of elderly SCI patients.^{20,37} The percentage of traumatic SCI patients over 60 years of age has increased from 4.6% in the 1970s to 13.2% in the 2000s.¹¹ Past studies have shown that older patients, as compared to younger patients, have a higher rate of complications and death after SCI and are less likely to be independent in self-care at discharge.^{10,11,21,28,31,43} Reported mortality rates have been as high as 38.5%.¹⁶ These observed differences in outcomes have been ascribed to a higher incidence of comorbidities at the time of injury and lower functional reserve of major organ systems.^{11,21} However, there is significant diversity among older patients with regard to baseline health and potential for significant recovery.^{21,47} In this contemporary period, advances in ICU management, an increased understanding of SCI physiology, and a multidisciplinary approach may allow older patients to achieve better outcomes during the postoperative period.²¹

Surgeons may be reluctant to offer surgery to an older SCI patient given the high risk of complications and poor outcomes. There are too few contemporary studies examining perioperative in-hospital morbidity and mortality in elderly patients with SCI who have undergone surgical management.² Given current trends in surgical practice and modern medicine, we hypothesize that elderly patients have improved outcomes compared to those in previous studies and that elderly and younger patients may even attain similar outcomes. In this study, we closely examine the perioperative outcomes of SCI patients aged 70 years or older and compare them to outcomes in a younger cohort and in the literature.

Methods

The UCSF Committee on Human Research formally approved this study.

Patients

Consecutive adult patients with traumatic SCI treated at a single institution in the period from 2007 to 2017 were identified through retrospective review. Data regarding patients treated in the period from 2007 to 2014 were collected via review of the electronic medical record. Starting in 2014, patients consented to and were enrolled in a prospective longitudinal database, which was also searched. The study inclusion criteria were as follows: traumatic SCI, treatment under institutional SCI guidelines, admission to the ICU, and age over 18 years at the time of injury. Penetrating SCI was excluded. The standard of care for SCI at our institution involves admission to the ICU and maintenance of mean arterial pressures (MAPs) greater than 85 mm Hg for 5 days. Our standard practice is to not use steroids in SCI patients, per cervical SCI guidelines.¹⁹ Indications for surgery are ongoing compression of the

spinal cord or spinal nerves, deformity, and need for open reduction and/or spinal stabilization.

Data and Outcomes

Data on patient demographics, clinical characteristics, and surgical details were collected, including age (younger than 70 years or 70 years and older), sex (male or female), presence of traumatic brain injury (TBI), admission Glasgow Coma Scale (GCS) score, mechanism of injury, and American Spinal Injury Association Impairment Scale (AIS) grade (admission and discharge). Imaging findings included the presence of spinal cord hemorrhage and spinal column fracture. The data point regarding whether spinal cord hemorrhage was present was based on neuroradiology evaluation. Various MRI sequences, such as susceptibility-weighted imaging, were utilized by the radiology team to detect hemorrhage. Recorded surgical details included instrumentation, number of levels fused, number of levels decompressed, whether corpectomy/vertebral column resection (VCR) was performed, and approach (anterior only, posterior only, or combined anterior-posterior).

Primary outcomes included ICU stay, total hospital length of stay (LOS), perioperative complication, and in-hospital mortality. Perioperative complications were defined as any unexpected or unforeseen medical and/or surgical issues requiring additional intervention within the patient's hospital stay. The perioperative complications were further divided into medical or surgical complications. Common SCI complications were specified, including cardiac complications (arrhythmia and myocardial infarct), pneumonia, urinary tract infection (UTI), acute kidney injury (AKI), deep vein thrombosis (DVT)/pulmonary embolus (PE), stroke, and surgical site infection. Recorded deaths were those occurring during the hospital admission. Secondary outcomes included disposition and neurological improvement based on AIS grade at discharge. Disposition was defined as the place where a patient was transferred after completion of their acute medical and surgical needs: home, inpatient (acute transfer to another hospital), acute rehabilitation, or subacute nursing facility (SNF).

Statistical Analysis

The study cohort was divided into two groups according to age: < 70 years and ≥ 70 years. Descriptive statistics were used to define the cohort. Univariate statistics were employed to compare baseline variables and perioperative outcomes between the two age groups. For categorical outcomes the chi-square test was used, and for continuous outcomes the Student t-test was used. A p value < 0.050 was used as the threshold of statistical significance. All statistics were performed with SAS 9.4 (SAS Institute Inc.). Values are expressed as the mean ± standard deviation or as number (%), unless indicated otherwise.

Results

A total of 106 patients were included in the study: 83 patients younger than 70 years (mean age 45.8 ± 15.4 years, range 18–69 years) and 23 patients aged 70 years and older (mean 78.4 ± 6.0 years, range 70–88 years; Table

TABLE 1. Comparison of demographics, traumatic attributes, and SCI characteristics between young and elderly patients

Characteristic	Total	Age <70 Yrs	Age ≥70 Yrs	p Value
No. of patients	106	83	23	
Age in yrs	52.9 ± 19.4	45.8 ± 15.4	78.4 ± 6.0	<0.001
Male	77 (72.6)	63 (75.9)	14 (60.9)	0.152
TBI	21 (19.8)	16 (19.3)	5 (21.7)	0.793
Admission GCS score				0.510
13–15	83 (78.3)	65 (78.3)	18 (78.3)	
8–12	19 (17.9)	14 (16.9)	5 (21.7)	
<8	4 (3.8)	4 (4.8)	0 (0.0)	
Mechanism of injury				0.288
Fall	76 (71.7)	56 (67.5)	20 (87.0)	
MVC	15 (14.2)	14 (16.9)	1 (4.3)	
PVA	10 (9.4)	9 (10.8)	1 (4.3)	
Assault	5 (4.7)	4 (4.8)	1 (4.3)	
Level of injury				0.047
Cervical	81 (76.4)	59 (71.1)	22 (95.7)	
Thoracic	18 (17.0)	17 (20.5)	1 (4.3)	
Lumbar	7 (6.6)	7 (8.4)	0 (0.0)	
Spinal cord hemorrhage	10 (9.4)	8 (9.6)	2 (8.7)	0.891
Spinal column fracture	66 (62.3)	54 (65.1)	12 (52.2)	0.259
Fracture dislocation	20 (18.9)	16 (19.3)	4 (17.4)	0.553
Admission AIS grade*				0.902
A	40 (38.5)	32 (39.0)	8 (36.4)	
B	13 (12.5)	11 (13.4)	2 (9.1)	
C	19 (18.3)	15 (18.3)	4 (18.2)	
D	32 (30.8)	24 (29.3)	8 (36.4)	

MVC = motor vehicle collision; PVA = pedestrian versus automobile.

Values expressed as mean ± standard deviation or as number (%), unless indicated otherwise. Boldface type indicates statistical significance.

* Two patients were missing an AIS grade.

1). Overall mean age was 52.9 ± 19.4 years, and 72.6% of the patients were male. Overall, 19.8% of the patients had a diagnosis of TBI, and the distribution of GCS scores was 13–15 in 78.3%, 8–12 in 17.9%, and < 8 in 3.8%. The mechanisms of injury were falls (71.7%), motor vehicle accidents (14.2%), pedestrian versus automobile (9.4%), and assaults (4.7%). SCI occurred most frequently in the cervical spine (76.4% of cases), whereas thoracic and lumbar SCIs made up 17.0% and 6.6% of cases, respectively. Spinal cord hemorrhage was present in 9.4% of patients, and spinal column fractures were present in 62.3%. Fracture dislocations were present in 18.9% of cases. The distribution of admission AIS grades was as follows: A in 38.5%, B in 12.5%, C in 18.3%, and D in 30.8%. In a comparison of these variables between the two groups, the only significant difference was in the level of injury; elderly patients experienced a higher proportion of cervical SCIs than the young patients (95.7% vs 71.1%, $p = 0.047$).

Table 2 provides information on the surgical procedures performed. Overall, 93.4% of patients underwent spinal in-

TABLE 2. Comparison of surgical procedures between young and elderly patients

Parameter	Total	Age <70 Yrs	Age ≥70 Yrs	p Value
No. of patients	106	83	23	
Fusion/spinal instrumentation	99 (93.4)	79 (95.2)	20 (87.0)	0.160
No. of levels fused	4.8 ± 2.9	4.8 ± 2.8	4.8 ± 3.4	0.980
No. of levels decompressed	2.7 ± 1.6	2.5 ± 1.6	3.3 ± 1.6	0.034
Corpectomy/VCR	13 (12.3)	11 (13.3)	2 (8.7)	0.556
Approach				0.158
Anterior	16 (15.1)	15 (18.1)	1 (4.3)	
Posterior	72 (67.9)	56 (67.5)	16 (69.6)	
Anterior-posterior	18 (17.0)	12 (14.5)	6 (26.1)	

Values expressed as the mean ± standard deviation or as number (%), unless indicated otherwise. Boldface type indicates statistical significance.

strumentation/fusion, and 6.6% underwent decompression only. Of the 106 patients, 12.3% underwent a corpectomy/VCR. The mean numbers of levels fused and decompressed were 4.8 and 2.7, respectively. An anterior approach was performed 15.1% of the time, and posterior approaches occurred in 67.9% of cases. A combined anterior-posterior approach was performed in 17.0% of cases. There were no significant differences in the instrumentation rate, number of levels fused, number of levels decompressed, rate of corpectomy/VCR, or approach between the young and elderly groups.

Table 3 compares the perioperative outcomes and endpoints between young and elderly patients. Overall, the ICU stay was 13.1 days and hospital LOS was 23.0 days. Young and elderly patients had similar ICU stays (13.1 vs 13.3 days, respectively, $p = 0.948$) and hospital LOSs (23.3 vs 21.7 days, $p = 0.793$). Of the 106 patients, 50.0% experienced at least one complication during their hospital course and 4 patients died, resulting in a cohort mortality rate of 3.8%. Elderly patients had a significantly higher rate of complications than the young group (73.9% vs 43.4%, $p = 0.010$). Similarly, older patients had a significantly higher mortality rate than the young patients (13.0% vs 1.2%, $p = 0.008$). Most patients were either discharged to an acute rehabilitation center (34.9%) or transferred to another acute care hospital (31.1%). Only 14.2% of patients were discharged home, and 11.3% were discharged to an SNF. Elderly patients had significantly lower rates of discharge home ($p = 0.029$); in fact, none (0.0%) of the elderly patients were discharged home compared to 18.1% in the young group.

Discharge AIS grade and change in AIS grade are shown in Table 3. There were no significant differences in AIS grade distribution or change in AIS grade between the two groups. A similar proportion of elderly and young patients improved (45.5% vs 40.2%, respectively), remained unchanged (50.0% vs 57.3%), and worsened (4.5% vs 2.4%) in their AIS grade at the time of discharge.

Table 4 provides further details regarding the types of complications encountered in the SCI patients. Medical complications occurred in 49.1% of cases. The overall rate of surgical complications was 7.5%; the majority were

TABLE 3. Comparison of perioperative outcomes between young and elderly patients

Parameter	Total	Age <70 Yrs	Age ≥70 Yrs	p Value
No. of patients	106	83	23	
ICU stay in days	13.1 ± 15.5	13.1 ± 16.0	13.3 ± 14.0	0.948
Hospital LOS in days	23.0 ± 24.8	23.3 ± 26.9	21.7 ± 15.1	0.793
Patients w/ complication(s)	53 (50.0)	36 (43.4)	17 (73.9)	0.010
Death	4 (3.8)	1 (1.2)	3 (13.0)	0.008
Disposition				0.029
Rehabilitation	37 (34.9)	29 (34.9)	8 (34.8)	
Transfer to another hospital	33 (31.1)	27 (32.5)	6 (26.1)	
Home	15 (14.2)	15 (18.1)	0 (0.0)	
SNF	12 (11.3)	6 (7.2)	6 (26.1)	
Other	9 (8.5)	6 (7.2)	3 (13.0)	
Discharge AIS grade*				0.951
A	26 (25.0)	22 (26.8)	4 (18.2)	
B	9 (8.7)	7 (8.5)	2 (9.1)	
C	21 (20.2)	16 (19.5)	5 (22.7)	
D	39 (37.5)	30 (36.6)	9 (40.9)	
E	9 (8.7)	7 (8.5)	2 (9.1)	
Change in AIS grade				0.522
Improved	43 (41.3)	33 (40.2)	10 (45.5)	
Same	58 (55.8)	47 (57.3)	11 (50.0)	
Worse	3 (2.9)	2 (2.4)	1 (4.5)	

Values expressed as the mean ± standard deviation or number (%), unless indicated otherwise. Boldface type indicates statistical significance.

* Two patients missing AIS grade.

wound infections with some requiring washout, and one patient had hardware failure requiring reoperation. There was no significant difference in surgical complication rates between the young and the elderly (6.0% vs 13.0%, $p = 0.259$). Pneumonia and UTI were the most common complications encountered, occurring in 23.6% and 21.7% of patients, respectively. Other complications occurred less frequently: cardiac (4.7%), AKI (1.9%), DVT/PE (6.6%), stroke (0.9%), and surgical site infection (5.7%). Both young and elderly patients experienced a similar rate of these complications.

Two representative cases are illustrated in Figs. 1–3. The first case is a 79-year-old female with hypertension, diabetes, congestive heart failure, and hyperlipidemia, who presented with significant weakness in all extremities and was only able to wiggle her fingers and toes after a fall down 12 stairs. Her admission AIS grade was B. Figure 1A shows a hairline, nondisplaced fracture of the C3 spinous process and 4-mm retrolisthesis at C3–4 with associated spinolaminar malalignment, and Fig. 1B shows focal disruption of the anterior longitudinal ligament with partial disruption of the ligamentum flavum, interspinous edema, and posterior disc herniation at C3–4. There is resultant severe spinal canal stenosis with cord compression and hemorrhagic cord contusion centered at this level.

TABLE 4. Comparison of specific perioperative complications between young and elderly patients

Parameter	Total	Age <70 Yrs	Age ≥70 Yrs	p Value
No. of patients	106	83	23	
Complication				
Medical	52 (49.1)	37 (44.6)	15 (65.2)	0.080
Surgical	8 (7.5)	5 (6.0)	3 (13.0)	0.259
Specific complication				
Arrhythmia/MI	5 (4.7)	3 (3.6)	2 (8.7)	0.309
Pneumonia	25 (23.6)	18 (21.7)	7 (30.4)	0.382
UTI	23 (21.7)	16 (19.3)	7 (30.4)	0.251
Acute renal failure	2 (1.9)	2 (2.4)	0 (0.0)	0.452
DVT/PE	7 (6.6)	5 (6.0)	2 (8.7)	0.648
Stroke	1 (0.9)	1 (1.2)	0 (0.0)	0.597
Surgical site infection	6 (5.7)	4 (4.8)	2 (8.7)	0.477

MI = myocardial infarct.

MRI was consistent with a Brain and Spinal Injury Center (BASIC) score of 4.⁴⁴ She was taken emergently to the operating room for C2–5 laminectomy and C3–4 lateral mass instrumentation and fusion. She was kept in a collar, admitted to the ICU, and managed via established SCI protocols with MAP goals at all times. Five days from her injury, she underwent a planned second-stage C3–4 anterior cervical discectomy and fusion. Postoperative lateral radiography showed C3–4 anterior discectomy and posterior spinal fusion (Fig. 1C). She had no complications and was transferred to an acute care hospital. She had improvement of strength in her right upper and lower extremities but remained AIS grade B at the time of discharge.

The second case was the oldest patient in the elderly cohort. He was an 88-year-old male with hypertension and a history of esophageal cancer who had been struck by an automobile while crossing the street and reported an immediate inability to move both arms and legs. His strength started to improve by the time he reached the emergency department. On examination, he had 4/5 interosseous strength and 4+/5 grip strength on both sides. He reported right shoulder and arm hyperalgesia. His presentation AIS grade was D. Initial MRI showed C3–7 multilevel severe central stenosis with ongoing spinal cord compression at C3–4 (Fig. 2A and B). There was also abnormal T2 signal at the level of C3–4, consistent with a BASIC score of 1.⁴⁴ At the level of C6–7, there was complete rupture and disruption of the discoligamentous tension band and bilateral C6 laminar fractures (Fig. 2B and C). He was taken to the operating room within 24 hours and underwent C3–7 laminectomy and C3–T1 posterior spinal instrumentation fusion with cervical lateral mass and thoracic pedicle screws (Fig. 3). He had no postoperative complications and was discharged to rehabilitation with a discharge AIS grade of E.

Discussion

The relationship between older age and surgical outcomes is not novel but is of great interest to various sur-

FIG. 1. Preoperative and postoperative images obtained in a 79-year-old female who presented with significant weakness in all extremities and was only able to wiggle her fingers and toes after a fall down 12 stairs. **A:** Midline sagittal CT image shows hair-line, nondisplaced fracture of the C3 spinous process (*white arrow*) and 4-mm retrolisthesis at C3–4 with associated spinolaminar malalignment at this level (*interrupted dashed line*). Preexisting advanced degenerative disc disease is seen at multiple levels. **B:** Sagittal fat-suppressed T2-weighted MR image shows focal disruption of the anterior longitudinal ligament (*arrowhead*) with partial disruption of the ligamentum flavum (*arrow*), interspinous edema, and posterior disc herniation at C3–4. There is resultant severe spinal canal stenosis with cord compression and hemorrhagic cord contusion centered at this level. **Inset:** Axial T2-weighted MR image corresponding to the level indicated by the *dashed line*. **C:** Postoperative lateral radiograph showing C3–4 anterior discectomy and posterior spinal fusion.

gical subspecialties including spine surgery.^{1,25,30,38} The spine literature broadly suggests that older patients tend to experience more medical complications and a higher mortality rate than younger patients.²⁷ In elective spine cases, older age is a risk factor for all complications, especially renal issues, UTIs, and surgical site infections.^{12,36} As life expectancy rises, spine surgeons will increasingly encounter older patients, and such patients have been less likely to undergo surgery for traumatic SCI. Ahn et al. performed a multicenter study of 1440 operative and nonoperative patients to determine the impact of older age on treatment decisions and outcomes.² In a multivariate analysis, these authors found that patients aged 65 years and older have lower odds of undergoing surgery (OR 0.39) and a longer time to surgery (37 hours vs 19 hours in younger patients).

More recently, there has been an emphasis in reducing bias against operating on elderly patients.³ Understanding the risks, especially as regards an increased complication rate, is essential in guiding elderly patients to recovery.

The decision on whether to operate in an elective spine patient versus a traumatic SCI patient is very different. Unlike in elective cases, the luxuries of careful patient selection and medical optimization are not present when treating a traumatic SCI patient. Elderly SCI patients frequently have underlying comorbidities and can present with multiorgan injuries.²³ It has been shown that the presence of comorbidities is a risk factor for death in patients with SCI; the Charlson Comorbidity Index has been identified as the most reliable predictor of in-hospital mortality (more than older age and complete motor SCI).¹⁷ In-hospital deaths

FIG. 2. Preoperative images obtained in an 88-year-old male with central cord syndrome after being hit by a motor vehicle. **A:** Axial T2-weighted MR image obtained at the level of C3–4, showing severe central stenosis with cord compression and T2 signal change. **B:** Midline sagittal T2-weighted MR image shows multilevel degenerative disc disease, and spondylosis from C3 to C7. There is also acute disruption and rupture of the discoligamentous complex of the C6–7 disc space. **C:** Sagittal CT scan showing mild widening of the C6–7 disc space, although spinal alignment is maintained.

FIG. 3. Upright lateral (left) and anteroposterior (right) radiographs obtained after decompression and stabilization in an 88-year-old man with central cord syndrome, demonstrating intact C3–T1 posterior spinal instrumentation.

in the setting of SCI are usually secondary to severe traumatic injuries or infection.²⁴ Overall, in-hospital mortality rates for patients with SCI range from 4.0% to 24.1%, depending on the country (7.5% in the United States), type of hospital, and mechanism of injury.^{9,17,22,34,39} Jain et al. analyzed a cohort of 63,109 traumatic SCI patients from the United States National (Nationwide) Inpatient Sample database and identified a significant decrease in mortality in the patients older than 85 years of age, from 24.2% in 1993 to 20.1% in 2012.²² These findings are promising, but these reported mortality rates include all admitted SCI patients, regardless of whether conservative, surgical, or comfort measures were taken. It is important to isolate and examine the outcomes of elderly patients who underwent surgery for SCI.

A paucity of studies compare perioperative and in-hospital outcomes between young and elderly patients with SCI. In a study by Ahn et al., 1116 patients younger than 70 years and 120 patients aged 70 years and older underwent surgery for SCI; the authors found that elderly patients had significantly higher mortality rates (4.2% vs 0.6%) than the younger group.² Other studies have also shown high in-hospital mortality rates in elderly patients following surgery for SCI, ranging from 14.3% to 38.5%.^{8,13,23} It has been reported that mortality rates remain higher in the elderly patients even at 3 weeks (25.0% vs 2.0%), 6 months (36.4% vs 2.2%), and 1 year (38.6% vs 3.1%) after SCI.¹⁶ Our study demonstrates a much lower mortality rate (13.0%) in elderly SCI patients than the rates in the literature. In 2007 Fassett et al. reported a 28% mortality rate in patients older than 70 years of age.¹³ In 2009 Furlan and Fehlings reported a mortality rate of 38.5% in SCI patients aged 65 years and older.¹⁶ In 2013 Daneshvar and colleagues reported an in-hospital mortality rate of 38% among SCI patients older than 60 years.⁸ There does seem to be a trend of declining in-hospital mortality rates in elderly patients. This may represent more aggressive care: rapid surgical decompression, rigorous ICU care, implementation of standardized SCI protocols, and active prevention strategies of known complications (e.g., DVT prophylaxis, early removal of Foley catheters, and mobilization to avoid decubitus ulcers).

The role of aggressive blood pressure support with MAP

goals over 85 mm Hg has been well described in SCI.^{19,40,45} Since Vale et al. first described the value of MAP goals, numerous other studies have reported both the benefits and the morbidity associated with the use of vasopressors.⁴⁵ Reddy and colleagues demonstrated that while beneficial, the use of vasopressors is particularly associated with increased cardiac complications in patients over 55 years old.⁴⁰ The optimal blood pressure in this SCI population remains to be determined.

Recent publications and our study showed that complication rates remain high for patients with SCI, especially for elderly individuals. Ahn et al. demonstrated significantly higher complication rates in the elderly (32.5% vs 22.2%) in their study.² Similarly, complication rates in the elderly in our study were significantly higher than those in the younger patients; the observed complication rate for the elderly was approximately 1.5 times that in the younger patients. Despite our higher complication rates in the elderly, we did not observe a difference in ICU stay or hospital LOS between the two age groups. This finding is different from those in prior studies, which have shown a longer LOS with increasing age (e.g., 18–25 years for 12.5 days and 65–69 years for 22.6 days).⁷ The most common complications among both age groups in our study were pneumonia and UTIs; SCI patients are inherently at risk for these particular complications given the frequent need for mechanical ventilation and Foley catheterization. Complication profile and hospital stay can be heavily influenced by the specific surgical approach and procedure performed. For example, staged procedures inherently require longer hospital stays, and more invasive procedures are associated with higher risk profiles. In the present study, both age groups were well matched as regards the specific approach and surgical procedure performed; therefore, it is unlikely that these account for the difference in outcomes observed between the two groups.

The impact of age on SCI, microenvironment inflammation, and neural recovery has been studied in detail. Studies have suggested that older age decreases the potential for, and delays, functional recovery of the nervous tissue following SCI.¹⁸ Age has been shown to exacerbate microglial activation, increase oxidative stress, and activate inflammatory genes.⁴⁶ In addition, in the setting of SCI, older age has been associated with decreased expression and production of antiinflammatory cytokines such as IL-10 in macrophages.⁴⁸ Despite these findings, the literature consistently supports the observation that elderly and younger patients have similar neurological outcomes and clinical recoveries.^{7,15,16,33,47} Our results support this observation, showing similar in-hospital recovery rates between elderly and young patients. Wilson et al. performed a retrospective study to define the impact of age on neurological outcomes.⁴⁷ Among 41 patients older than 65 years and 335 younger patients, they found no age-related differences in motor recovery and AIS grade at the 1-year follow-up; however, older patients had significantly lower Functional Independence Measure scores. Furlan and Fehlings also demonstrated findings of similar neurological outcomes but lower Functional Independence Measure scores in patients aged 65 years or older.¹⁶ Older and younger patients also showed similar sensory recovery and pain outcomes.

These findings corroborate our results in that no elderly patients were discharged home regardless of the discharge AIS grade. Given that the proportion of discharge AIS grades were similar between our two age groups, the observed difference in the rates of discharge home was likely attributable to multiple factors and not only the severity of SCI. Rather, for the elderly, other issues such as management of complications, chronic comorbidities, availability of care, and ability to perform tasks of daily living were important factors. Further dedicated studies are needed to clarify why elderly patients were not discharged home.

There are some drawbacks to this study related to sample size, nonrandomization of patients to surgery, and lack of long-term data. The overall cohort size was 106 patients, and only 23 of them were 70 years of age or older. This limits the ability to detect smaller magnitudes of differences in the outcomes assessed and to verify the presence of actual differences between groups. An example is the higher rates (approximately 1.5 to 2 times) of medical, surgical, and wound complications in the elderly group but a statistical analysis that did not demonstrate significance. It is most likely that there were insufficient numbers to prove statistical significance for these outcomes. However, a positive feature of the elderly cohort was an average age of approximately 78 years, which is quite representative of an “older” population. Additionally, most injuries occurred in the cervical region in the elderly group. Elderly patients are inherently at higher risk for cervical SCI because of the presence of multilevel degenerative disease causing cervical stenosis. Future studies may use matched cohorts to normalize this natural phenomenon. Because our study was not a randomized trial, a selection bias may exist; the elderly patients who underwent surgical intervention are those thought to have the potential to do well. In particular, it seems that a larger proportion of elderly patients in our cohort suffered ground-level falls as compared to historical cohorts that suffered multisystem trauma. Such demographic differences have the potential to account for the differences in mortality. However, this selection bias may not be an actual drawback but a representation of the modern management of SCI in elderly and critically ill individuals. The decision process in offering surgery to elderly SCI patients should carefully weigh the risks and benefits. In relation to this, injury severity measured by the injury severity score should be taken into account. Lastly, this study concentrates on the in-hospital and perioperative course and lacks outcome data after discharge. It is important to highlight that these findings are not generalizable to long-term outcomes but strictly represent in-hospital trends.

Conclusions

In a sample of younger and elderly SCI patients, this study shows that elderly patients have significantly higher rates of complications and mortality. The mortality rate of 13.0% among the elderly is lower than the published rates of 27%–38% and may represent aggressive surgical and postoperative ICU management. However, it is also important to emphasize and acknowledge that elderly patients still have worse complication and mortality rates

than those in younger patients. Elderly patients had 1.7 times and 10.8 times higher rates of complications and mortality, respectively, than the younger patients. Despite differences in complication and mortality rates, we did not observe differences in ICU stay or hospital LOS between the two groups. Discharge AIS grades and rate of neurological improvement were also similar between the groups. These findings suggest that select elderly patients, if treated aggressively, have a capability for neurological recovery similar to that in younger patients. However, elderly patients were uniformly discharged to assisted living facilities. Overall, elderly SCI patients can achieve fair perioperative outcomes. It may be appropriate to offer surgery to a patient despite an older age. At the same time, it is important to set appropriate expectations and emphasize that discharge directly home may not be possible. Additional studies are needed to substantiate the findings of this study given the small number of patients included in the elderly group. In particular, a large prospective multicenter study would be the most optimal to increase power and minimize biases in this cohort of patients.

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