



Morbidity and mortality of traumatic cervical spinal cord injuries in a geriatric cohort

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Abstract

Background Traumatic injuries are among the leading causes of death and disability worldwide. Major trauma presentations have seen a demographic shift recently from the young to the elderly, with significant associated neurological deficit.

Aims To review the presentation and outcome of elderly patients presenting with cervical spinal injuries and associated neurological deficit that underwent surgical intervention in order to optimise treatment strategies.

Methods A retrospective review was conducted at a national tertiary referral centre to analyse admission trends from June 2016 to July 2020 for outcomes of elderly patients (≥ 65) presenting with traumatic cervical spine injuries associated with spinal cord injuries (SCI). Demographic, clinical, and radiological characteristics were collected and analysed.

Results Forty-two patients met the inclusion criteria. The most common mechanisms of injury (MOIs) were falls from standing (38.1%) and falls from height (≥ 2 m) (33.3%). Complete SCIs had increased mean LOS (57.6 vs 21.6 days; $p=0.013$), postoperative complications (100% vs 60.6%; $p=0.022$), life-threatening complications (57.1% vs 9.1%; $p=0.001$), and 90-day mortality (37.5% vs 5.9%; $p=0.007$) compared to incomplete SCIs.

Conclusion Elderly patients with complete SCIs have poorer outcomes and mortality than those with less extensive SCIs. They require more resources, have greater risk of complications, and have higher mortality than those with incomplete SCIs, with subsequent implications on optimal treatment strategies. More robust studies are needed to derive improved risk stratification tools for geriatric patients with spinal injuries.

Keywords Geriatric · Morbidity · Mortality · Neurology deficit · SCI

Introduction

There has been exponential growth in the elderly population worldwide over the past number of decades and this trend is expected to continue for the foreseeable future. The worldwide population of individuals over 65 years old was estimated at 727 million in 2020. This number is projected to more than double to 1.5 billion by 2050 [1]. This will increase the percentage of the total population over 65 from 9.3 to 16% by mid-century, making up one-sixth of the world's population [1].

As well as being important demographically, advancing age is associated with worse outcomes following traumatic injuries [2]. Mortality is higher among this age group compared with all others due to age-related cofactors. There is estimated to be a 2.4–5.6 times greater risk of death compared with younger patients [2]. Data from the major trauma audit (MTA) shows a year-on-year increase in the number and percentage of total trauma admissions of the ≥ 65 age group in Ireland, with a significant proportion of patients admitted to hospital for traumatic spinal injuries [3].

Oftentimes, spinal injuries in elderly patients are treated conservatively due to the presence of comorbidities which may increase the risk of intraoperative morbidity [4]. Even in the presence of a neurological deficit associated with a spine fracture, the significant risk attributable to surgery often leads the treating clinician to pursue less invasive treatments. For example, corticosteroids and other pharmacological therapies can be used to limit spinal cord injury and

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motor neuron loss in patients with mild central cord syndrome, rather than proceeding with surgical decompression [4]. However, in the presence of a major neurological deficit, surgical intervention is often warranted, as it has sometimes been associated with an improvement in neurological recovery in all but the most severe spinal cord injuries [4].

Currently, no consensus exists regarding the optimal treatment strategy for elderly patients presenting with cervical injuries and associated neurological deficit [4–6]. The decision to pursue surgical or conservative approaches to treatment is often difficult and requires further characterisation of spinal cord injuries in this age group [4].

The premise of this paper is to review the presentation and outcome of elderly patients presenting with cervical spinal injuries and associated neurological deficit that underwent surgical intervention at a large tertiary referral centre, with a secondary goal to optimise treatment protocols and logistics planning for the inevitable increasing incidence of similar injuries in this cohort.

Methods

This was a retrospective review of prospectively gathered data from a national tertiary referral centre for spine injuries. Data was gathered from the database for all patients who met the inclusion criteria.

Inclusion criteria were as follows:

- Aged ≥ 65 years
- Traumatic injury mechanism
- Injury pertaining to the cervical spine
- Present neurological deficit or spinal cord injury (SCI)
- Admission for surgical management

Exclusion criteria were as follows:

- Patients aged 64 years and under
- Non-cervical spine injuries
- Presenting without spinal cord injury (SCI)
- SCI caused by non-traumatic or degenerative myelopathy
- Patients who were managed conservatively
- Patients not admitted to our institution

Variables collated include patient age, gender, mechanisms of injury (MOI), location of injury, coexisting injuries, American Spinal Cord Injury Association (ASIA) grade, and method of treatment. The surgical procedure undertaken, total length of stay (LOS), ICU (intensive care unit) and HDU (high-dependency unit) length of stay (ICU/HCD LOS), post-operative complications, and 5-point modified frailty index (MFI-5) were also documented. Data to complete this information was collected from the institutional database on spinal

injuries admitted to our tertiary referral centre and radiology archives for associated imaging.

Complications were classified according to the Clavien-Dindo classification system and grouped as follows: classifications I and II were considered minor complications, classifications IIIa and IIIb were considered major complications, classification IVa, IVb, and V were considered life-threatening complications.

Mortality was determined using a combination of local patient records and a national obituary database. Follow-up timepoints of 3 months and 1 year were used for this study to define acute post-injury mortality and early mortality. Comparative data was analysed by employing students' *t*-test and Z-test of proportions where necessary. Mortality data was analysed and depicted using Spearman's correlational analysis for non-parametric data and Kaplan–Meier survival analysis. Graphs were generated using GraphPad Prism 6.01 software.

Aims

The primary aim of this research was to analyse trends in admissions of elderly patients (≥ 65 years) with traumatic cervical spine injuries, with neurological deficits that required surgical intervention at a national tertiary referral centre for spinal injuries from 2016 to 2020, assessing changing trends in admissions and referral demographics. The secondary goal was to identify factors which can be used to optimise treatment protocols and logistical planning for the inevitable increasing incidence of similar injuries in this cohort.

Results

(i) *Demographics of admissions*

A total of 42 patients met the inclusion criteria during the four-year period (July 2016–June 2020) and were initially included in the study. Three patients were excluded from post-surgery analysis on the basis that they did not undergo surgery. Two patients were admitted for surgery; however, their treatment plan was later revised to conservative management. One patient passed away from their injuries before surgery was performed (Fig. 1). Table 1 presents the demographic characteristics of these patients on admission.

There was a correlation between mechanism of injury and patient age group. 70% (7/10) of those over 80 were admitted for cervical surgery following a fall from standing compared with 28% (9/32) of those aged between 65–79 years old ($p = 0.0088$).

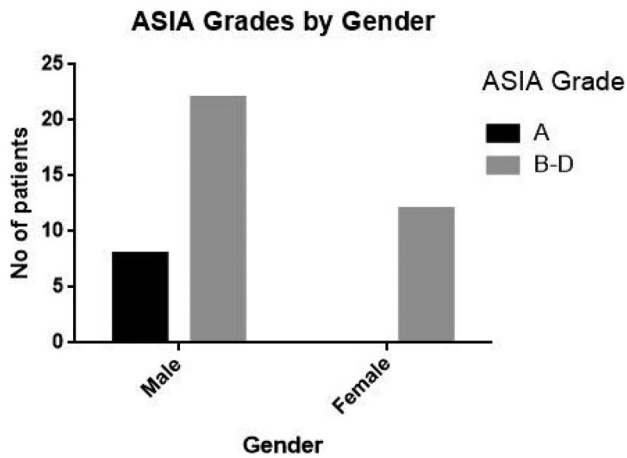


Fig. 1 Graph showing the number of patients of each gender who presented to the tertiary spine referral unit from 2016 to 2020 with either ASIA grade A, or ASIA grade B, C, or D. 18.9% of males presented with ASIA grade A compared to 0% of females ($p=0.035$)

Patients admitted from road traffic accidents (RTAs) were more likely to have a complete SCI compared with those who were admitted because of a fall from standing ($p=0.006$) or because of a fall from a height ($p=0.0315$). 50% (5/10) of RTA victims had ASIA A on admission, compared with 6.25% (1/16) of those who were admitted following a fall from standing and 14.3% (2/14) of those who suffered a fall from a height.

Readmission to the unit was almost always for second surgery (83.4%). Three of six patients (50%) were re-operated on to extend fixation due to progressive neurological deterioration. Average deterioration was by one ASIA scale grade. Other indications for secondary surgeries included hematoma evacuation (without associated neurological deficit), elective revision for head tilt, and further dens fixation secondary to instability on postoperative imaging (Table 2).

(ii) Overall length of stay (LOS)

No significant difference was observed between LOS for octogenarians (aged 80+) and younger geriatric patients (aged 65–79). LOS was significantly longer for patients with complete SCI, compared with patients who had an incomplete SCI (57.6 days vs 21.6 days; $p=0.01$) (Fig. 2).

(iii) ICU/HDU LOS

ICU/HDU LOS was found to be significantly longer for patients with ASIA A on admission compared with those with ASIA B–D (28.5 days vs 5.7 days; $p<0.001$). This is despite one patient with ASIA A

Table 1 Demographics and descriptive analysis of patients ≥ 65 years old with traumatic cervical spine injuries who had neurological deficits and were admitted to the national tertiary referral centre for spinal injuries for surgical fixation

| Parameter | Number of patients (n) | % of total patient cohort |
|---|------------------------|---------------------------|
| Total | 42 | 100% |
| Year admitted | | |
| 2016–2017 | 7 | 16.67% |
| 2017–2018 | 15 | 35.7% |
| 2018–2019 | 15 | 35.7% |
| 2019–2020 | 5 | 11.9% |
| Gender | | |
| Male | 30 | 71.4% |
| Female | 12 | 28.6% |
| Mechanism of injury (MOI) | | |
| Fall from height or down stairs (> 2 m) | 14 | 33.3% |
| Fall from a standing position (< 2 m) | 16 | 38.1% |
| Road traffic accident (RTA) | 10 | 23.8% |
| Other | 2 | 4.8% |
| Location of injury | | |
| Including C1–C3 vertebrae | 13 | 30.95% |
| Excluding C1–C3 vertebrae | 29 | 69.05% |
| Both atlanto-axial and subaxial vertebrae | 6 | 14.3% |
| Modified frailty index 5-point | | |
| 1 | 12 | 28.6% |
| 2 | 17 | 40.5% |
| 3 | 7 | 16.7% |
| 4 | 6 | 14.3% |
| 5 | 0 | 0% |
| ASIA score on admission | | |
| A | 8 | 19.05% |
| B | 6 | 14.28% |
| C | 11 | 26.19% |
| D | 17 | 40.48% |
| Surgical approach (n = 39) | | |
| Anterior | 26 | 59.6% |
| Posterior | 10 | 26.9% |
| Anterior + posterior | 3 | 7.7% |
| Readmission (n = 39) | | |
| < 1 month | 2 | 5% |
| < 3 months | 5 | 12.5% |
| < 6 months | 6 | 15% |
| Second surgery (n = 39) | 7 | 17.95% |
| Mortality | | |
| In hospital | 4 | 9.5% |
| < 3 months | 5 | 11.9% |
| < 1 year | 7 | 16.6% |
| ASIA grade | | |
| ASIA A | | |
| Males | 8 | 19.05% |

Table 1 (continued)

| Parameter | Number of patients (<i>n</i>) | % of total patient cohort |
|-----------------|---------------------------------|---------------------------|
| Females | 0 | 0% |
| Aged 65–79 | 6 | 14.3% |
| Aged 80+ | 2 | 4.76% |
| ASIA B–D | | |
| Males | 22 | 52.4% |
| Females | 12 | 28.6% |
| Aged 65–79 | 26 | 61.9% |
| Aged 80+ | 8 | 19.05% |

passing away before surgery was performed, and one further patient with ASIA A passing away the morning after surgery (ICU LOS = 1). Excluding these patients whose ICU LOS were shortened due to a negative outcome, the average ICU/HDU for this category was 33.2 days compared with 5.7 days for ASIA B–D ($p < 0.001$).

There was no significant difference in ICU/HDU LOS between age groups or between genders. However, there is a trend toward males spending an increased length of time in ICU/HDU ($p = 0.053$, 12.53 days for males vs 3.58 days for females).

(iv) Postoperative complications

Analysis was carried out to assess the relative risk of complications between younger geriatrics (aged 65–79 years) and older geriatrics (aged ≥ 80). Younger geriatrics were more likely to suffer post-operative

Table 2 Table documenting average LOS and 95% Confidence Interval (95% CI) for subgroups of patients aged ≥ 65 with traumatic cervical injury and co-existing SCI at the unit between July 2016 and June 2020

| Patient group | Average LOS (days) |
|--------------------|--------------------|
| Total LOS | |
| Males | 35.5 |
| Females | 10.75 |
| ASIA A | 57.6 |
| ASIA B–D | 21.6 |
| 65–79 years | 24.8 |
| 80+ years | 25.5 |
| ICU/HDU LOS | |
| Males | 12.5 |
| Females | 3.6 |
| ASIA A | 28.5 |
| ASIA B–D | 5.7 |
| 65–79 years | 10.8 |
| 80+ years | 8.2 |

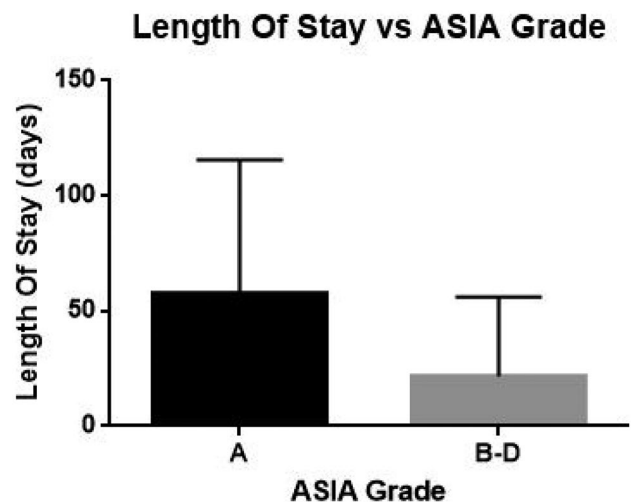


Fig. 2 Graph comparing mean and range of LOS of those who presented to the unit with cervical spine injury that required surgery with either ASIA A and ASIA B–D, between July 2016 and June 2020

complications following spinal surgery when compared to the older cohort (74.2% (22 patients) vs 44.4% (4 patients); $p = 0.04$). However, almost half of these complications were found to be minor. There were no discrepancies between genders experiencing post-operative complications. However, males were more likely than females to experience life-threatening post-operative complications or death (28.6% (8 patients) vs 0% (0 patients); $p = 0.019$), as defined by Clavien-Dindo grades IVa, IVb, and V. This may be since males were more likely to present with an ASIA grade of A ($p = 0.035$).

Patients with complete SCI were much more likely to have post-operative complications compared with those with incomplete SCI (100% vs 60.6%; $p = 0.02$). All patients who presented with ASIA A had some level of postoperative complications. This study also shows that patients who presented with ASIA A on admission were much more likely to suffer life-threatening complications than their counterparts with ASIA B–D (57.1% vs 9.1%; $p = 0.001$). 75% of complications in the acute phase of spinal cord injury were respiratory related. Of these, 5 patients required tracheostomy insertion, and a further three required short-term ventilator support via intubation. 25% of acute phase complications were cardiovascular in nature.

Assessing mechanism of injury and complications, those who had been involved in RTAs had a higher rate of life-threatening complications compared with those involved in low-impact falls from standing (40% vs 6.7%; $p = 0.02$), potentially due to the high energy, polytraumatic nature of the MOI. There was a similar difference between RTAs and all types of falls (40% vs

10.3%; $p=0.017$). There was no difference in the rate of complications between patients experiencing high-impact falls (> 2 m) and low-impact falls ($p > 0.05$).

(v) Mortality

There was a significant difference in mortality between patients who presented with a complete SCI due to their injuries and those who presented with incomplete SCI at the 90-day timepoint (37.5% (3 of 8 patients) vs 5.9% (2 of 34 patients); $p=0.007$) and at the 365-day timepoint (37.5% (3 of 8 patients) vs 11.8% (4 of 34 patients); $p=0.04$) post-injury. There were no deaths in the ASIA A subgroup after 90 days. The difference in mortality between those with ASIA B–D and ASIA E was insignificant (Fig. 3).

Interestingly, there was no significant difference between younger and older geriatrics ($p=0.36$), genders ($p=0.18$), vertebral injury level ($p=0.11$), pre-existing stenosis ($p=0.15$), or alcohol consumption ($p=0.95$) when considering mortality at either timepoint.

Regarding characteristics of the five patients who died within 90 days, all were male, had cervical injuries located from C5 to C7, and had ASIA grades of A–C. Clavien-Dindo complication scores ranged from II to V, with two patients dying as inpatients in the unit, both with ASIA A. 80% of these patients had Clavien-Dindo classification scores of III to V, compared to just 27% of patients who survived 90 days after surgery. The average 5-point modified frailty index (MFI-5) score of these patients was 2.8 with a mode of 2. This is opposed to an average MFI-5 score of 1.9 and mode of 2 for patients who did not die within 90 days. This is only marginally statistically significant at $p=0.049$. Interestingly, three (60%) of the patients who died underwent single-level decompression and fusion. Only one patient (20%) required both ACDF+PCDF.

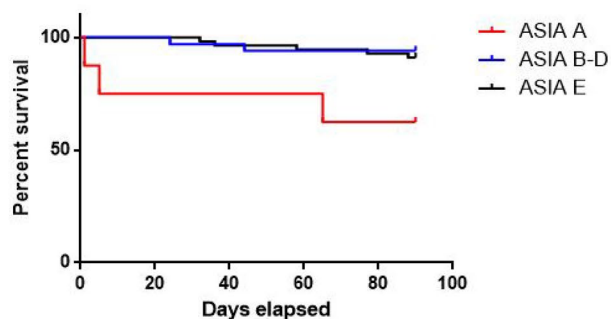
However, peri-operative cardiovascular complications led to a decision to terminate the procedure following single-level posterior fixation.

Discussion

An altered physiological response to trauma may be evident for geriatric patients [2, 7]. Factors such as ageing, reduced physiological reserves, comorbidities, medications, and frailty can all influence the presentation of major trauma in older people [2]. They are particularly more at risk of spinal injuries due to poorer osseous mineralisation, osteoporosis, and increased spinal rigidity, among other anatomical differences [2].

Spinal injuries in those over 65 are commonly multilevel in nature and occur because of apparently minor traumas, as falls from < 2 m and falls from standing account for 75% of traumatic presentations [2, 8]. Particularly, hyperextension injuries suffered secondary to a fall often result in the cervical spine being injured in these patients [8, 9]. This study demonstrated a correlation between mechanism of injury and patient age. 70% (7/10) octogenarians were admitted for cervical surgery following a fall from standing compared with 28% (9/32) of those aged between 65–79 years old ($p=0.0088$). This strongly implies that the older age group is more at risk than the younger age group from low-impact falls. This is consistent with previous studies which attribute the increased occurrence of injuries to age-related decline in musculoskeletal function, neurological function, and bone flexibility in the elderly [3, 4, 9–11]. This cumulatively leads to complicated decision-making processes for determining optimal treatments in this cohort, whether it be surgical, conservative, or palliative [1, 4]. However, these low-impact injuries can often prove unstable, warranting prompt imaging and surgical intervention [2, 12].

Kaplan Meier Survival for ASIA Grade at 90 days



Kaplan Meier Survival for ASIA Grade at 365 days

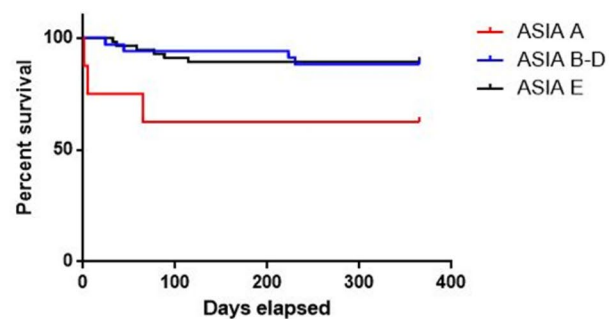


Fig. 3 Kaplan–Meier mortality charts for patients separated by ASIA score at 90-day and 365-day timepoints

Typically, associated neurological deficits are a strong indication for surgical intervention. Yet, geriatric patients can sometimes represent poor surgical candidates. This is secondary to associated co-morbidities and aforementioned reasons. Additionally, there has been a recent desire to informally include consideration of frailty status and accompanying sarcopenia of geriatric candidates prior to undergoing surgery, as increased frailty and sarcopenia have been identified as strong predictors of poor outcomes in both conservative and operative cohorts [10, 13–15]. Although several traditional and novel grading tools exist for evaluating the presence and severity frailty and sarcopenia, there remains a lack of consensus on the most efficacious grading system, with none particularly relating to spine surgery patients. This presents a major problem as our review convincingly demonstrated that octogenarians are more prone to low-impact SCIs than those patients aged 65–79. Currently, morbidity and mortality rates of geriatric SCI patients remain high despite recent technological advancements, as shown by postoperative rates of complications, reoperation, and mortality in our study. Therefore, there is a need for improved risk stratification tools for geriatric spine patients, inclusive of clinical and injury characteristics, in addition to frailty and sarcopenic status. This need for improved risk stratification systems is further corroborated by the risk of morbidity and mortality of conservative management of geriatric cervical spinal injuries reported throughout the literature [15–18].

Regarding our cohort specifically, what is even more concerning is that 37.5% of complete SCI injuries succumbed to their injuries within 90 days, compared to an overall mean LOS of 57.6 days. The significant acute-phase mortality rate coupled with the extensive LOS of those with ASIA A raises the question of whether it is in a patient's best interest proceeding with surgical intervention rather than offering palliative care. Considering means, those who succumbed to their injuries within 90 days spent two-thirds of their final months admitted in the hospital. Surgeons must consider this during initial consultation, and the risk–benefit balance of operating on an individual with significant SCI and disability should be considered. Interestingly, patients who passed away within 90-days of injury were deemed more frail per mFI-5 score (2.8 versus 1.9). This further supports calls for greater interest in the derivation of novel applicable risk-stratification tools for geriatric spinal injuries, particularly an ageing demographic and more complex spine surgeries being performed in the modern era. Current informal methods of choosing optimal treatment strategies are insufficient, as evident by high rates of morbidity and mortality for both conservative and surgical geriatric cohorts in the literature.

A potential limitation of our study is that cases were identified retrospectively from a single institution. The retrospective extraction of patient data, as performed in this study, is

subject to limitations. For example, many MRI and CT scans were completed in other institutions before referral to our centre and these scans were not retrievable from our database. Secondly, as this is a tertiary institution for patients with spinal injuries who required surgery, it is possible that this collection of cases may not fully represent an accurate cross-section of patients with spinal injuries. Certain situations may occur that prevent a patient from being admitted to the unit, such as the patient being deemed too ill for transfer, the patient being listed for palliative care in their local hospital, the patient being recommended for conservative management, or patients receiving treatment by orthopaedic teams in their local centres. Lastly, patient presentations for 2020 were expectedly affected by the presence of COVID-19 and social restrictions at the time. Nevertheless, the risk–benefit balance of operating on an individual with significant SCI, associated disability, and overall poor prognosis must be considered for future reference. It is imperative to elucidate clinical and injury-related risk factors for increased risk of mortality and to fully establish a stratified index for which to predict a patient's post-operative recovery and mortality risk. Only this will allow practicing spine surgeons to optimise decision-making for geriatric spine patients with SCI.

Conclusions

As expected, patients who have more extensive spinal cord injuries have poorer outcomes than those with incomplete or absent SCI. Complete SCI puts patients at greater risk of longer LOS, greater levels of postoperative complications, particularly life-threatening complications, and death at both 90-day and 365-day timelines. Males were more at risk of complete SCI, longer LOS, and life-threatening complications when compared with females. Paradoxically, younger geriatric patients (aged 65–79) were more at risk of complications compared with their older counterparts.

More robust prospective studies are needed to identify reliable risk factors that increase the risk of mortality within 90 days for patients presenting with cervical injuries that are associated with a complete neurological deficit. These results demonstrate, however, that patients presenting with complete neurological deficits require more resources, have greater risk of complications and life-threatening complications, and have greater mortality rates than those with incomplete neurological deficits. This has implications on decision-making regarding whether surgery should be performed on these patients or whether they should be treated palliatively.

Availability of data and material Available upon request.

Code availability None.

Declarations

Conflict of interest The authors declare no competing interests.

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