Cervical Spinal Cord Injury at the Victorian Spinal Cord Injury Service: Epidemiology of the Last Decade

Simon C.P. Lau¹, Nathan G. Myhill¹, Rekha Ganeshalingam¹ and Gerald M.Y. Quan¹,²

¹Department of Surgery, Austin Health, Melbourne, Victoria, Australia. ²Department of Spinal Surgery, University of Melbourne.

ABSTRACT
INTRODUCTION: Cervical spinal cord injury (CSCI) is a significant medical and socioeconomic problem. In Victoria, Australia, there has been limited research into the incidence of CSCI. The Austin Hospital's Victorian Spinal Cord Injury Service (VSCIS) is a tertiary referral hospital that accepts referrals for surgical management and ongoing neurological rehabilitation for south eastern Australia. The aim of this study was to characterise the epidemiology of CSCI managed operatively at the VSCIS over the last decade, in order to help fashion public health campaigns.

METHODS: This was a retrospective review of medical records from January 2000 to December 2009 of all patients who underwent surgical management of acute CSCI in the VSCIS catchment region. Patients treated non-operatively were excluded. Outcome measures included: demographics, mechanism of injury and associated factors (like alcohol) and patient neurological status.

RESULTS: Men were much more likely to have CSCI than women, with a 4:1 ratio, and the highest incidence of CSCI for men was in their 20s (39%). The most common cause of CSCI was transport related (52%), followed by falls (23%) and water-related incidents (16%). Falls were more prevalent among those >50 years. Alcohol was associated in 22% of all CSCIs, including 42% of water-related injuries.

DISCUSSION: Our retrospective epidemiological study identified at-risk groups presenting to our spinal injury service. Young males in their 20s were associated with an increased risk of transport-related accidents, water-related incidents in the summer months and accidents associated with alcohol. Another high risk group were men >50 years who suffer falls, both from standing and from greater heights. Public awareness campaigns should target these groups to lower incidence of CSCI.

KEYWORDS: cervical spine, trauma, Victoria Australia, injury, incidence, epidemiology


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CORRESPONDENCE: simon.laucmh.org.au

Introduction
Cervical spinal cord injury (CSCI) is a significant worldwide problem. It usually involves lifelong disability and a requirement of ongoing support services. Moreover, a cervical level of injury has the potential of causing both upper and lower limb paralysis, which has more severe ramifications when compared with thoracic or lumbar spinal cord injury, where arm strength and function are spared. The Australian Institute of Health and Welfare's (AIHW) Spinal Cord Injury Australia 2007–08 report has shown that a cervical level of injury contributes approximately half of all spinal cord injuries in Australia. Furthermore, CSCI clearly places a significant financial burden on the community. In Australia, the average overall cost for acute and ongoing treatment is $9.5 million per patient and nationwide total lifetime costs of CSCI in 2008 were estimated at $1.3 billion. At present, no therapies exist that have had a significant impact on recovery of neurological function in these patients.

It has long been recognized that monitoring of trauma incidence can play a role in its prevention. In this regard, epidemiological studies into CSCI can provide insight into incidence, as well as identify high risk groups, activities and...
periods of acute CSCI. They can also act as a determinant into efficacy of preventative interventions. Previous studies have identified motor vehicle accidents (MVAs) and water-related accidents as high-risk activities for CSCI, particularly among young people. In Victoria, various public organizations, such as Water Safe Victoria and the TAC, have investigated risky behaviors and fashioned public awareness campaigns based around road toll and drowning statistics. However, CSCI has not been specifically considered when it comes to fashioning trauma prevention campaigns in Victoria.

In our retrospective, descriptive study, we have assessed the population with CSCI who presented to our tertiary care centre and were managed with surgical intervention. Austin Health houses the Victorian Spinal Cord Injury Service (VSCIS), and provides surgical management of CSCIs in Victoria, Tasmania and the Riverina region of New South Wales. This comprises a total population of approximately 5 million. While not all CSCI surgery in Victoria occurs at the VSCIS, it is routine for CSCIs requiring prolonged specialized rehabilitative care in these regions to be transferred to our service. Our goals were to characterize any changes in the epidemiology of CSCI over the past decade, with a particular focus on mechanism of injury, demographic factors like age and gender, and seasonal variation. We were particularly interested in identifying risk factors for CSCI, which could be used to help fashion preventative public health awareness campaigns.

Results

Demographics. 206 patients were operatively treated for CSCI throughout our study period. There were 169 (82.0%) males and 37 females (18.0%) with a median age of 36 years (range 12–90 years). Male to female ratio was 4:1. CSCI in men was most common in the third decade, with 31.3% of incidents. Women, by contrast, were more likely to suffer CSCI in their seventh decade (18.9%), with a second peak in the third decade (16.2%) (Fig. 1).

Complete versus incomplete injuries. There were a total of 70 (34.0%) complete neurological injuries, 133 (64.6%) incomplete neurological injuries and 3 (1.5%) injuries which did not result in any neurological deficit. Age was inversely proportional to the neurological status with 33 (47.1%) complete injuries occurring in those less than 30 years old (Fig. 2). Men were more likely to suffer complete CSCI, with 61 events (87.1%), compared with 9 events (12.9%) for women (relative risk 1.48). There was no progression from incomplete to complete injury, or vice versa, throughout the study period. As a percentage of total CSCIs, complete injury was consistently between 30 and 42.9% each year.

Incidence. The prevalence of CSCI was stable over the 10-year study period, with the annual incidence ranging from 2.60 to 5.25 CSCIs per 100,000 individuals (Fig. 3).

Methods

This was a retrospective review of the medical records of all patients who were operatively managed for acute cervical spinal cord injury from January 2000 to December 2009 in the VSCIS at the Austin Hospital. Patients who were managed non-operatively were excluded from the study. The patient cohort was identified via a search of discharge coding from the Austin Health Information Service. Data collected included patient age and gender, mechanisms of injury causing the acute traumatic CSCI, whether alcohol was involved, and patient neurological status. The mechanisms of injury were divided into five categories: transport, falls, water-related, sports and other. Transport-related injuries consisted of accidents involving cars, trucks, motorcycles, pedal bicycles and pedestrians who were struck by moving vehicles. Falls included falls from a standing position and falls from a height such as from ladders, trampolines, stairs and horses. Water-related injuries included diving into shallow water and jet-ski accidents. Sports-related injuries consisted of skiing, rugby and Australian Rules Football (AFL) injuries. Other injuries included industrial accidents, assaults and unknown aetiologies.

Figure 1. The age versus percentage of males and females who were managed operatively for CSCI at the VSCIS from 2000–2009.
of \(-0.0272/100,000\) per year. Annual percentage change (APC) over the study was calculated at \(-0.16\%\) (95% CI \(-16.6, 16.3\)).

**Mechanism of injury.** The most common cause of CSCI was transport related (106, 51.5%). This was followed by falls (47, 22.8%) and water-related injuries (33, 16.0%). Figure 4 demonstrates the higher incidence of CSCI from MVA and water-related incidents among a younger demographic (<30 years). Of the MVA CSCIs in the third decade, males comprised 93.1% of the events (27 events). Conversely, falls were over represented among older patients, aged >50 years (34, 72.3%). Of the transport-related accidents, 64 (60.4%) involved cars, 21 (19.8%) involved motorbikes, 16 (15.1%) involved push bicycles, 3 (2.8%) involved other MVAs, and 2 (1.9%) were pedestrians hit by a moving vehicle. There was an increase in car-related CSCIs in winter (20, 31.3%) compared to the mean (16) and an increase in push bike CSCIs in the autumn (6, 37.5%) versus mean (4) (Fig. 5). Of water-related CSCIs, 66.7% (22) occurred in summer. Males comprised 81.8% (27) of these events. There was also a clear peak in incidence of alcohol-related CSCI in the summer months, with 37.0% (17) of all incidents. There were no CSCIs in those less than 50 years who fell from a standing position. With regards to falls from a height, there were peaks in those <30 and >50 years. These demographics were 87.5% (7) and 63.6% (7) male respectively. In the younger demographic, the falls mechanism was due primarily to trampoline-related incidents (4); whereas, with the older demographic it was typically due to intoxicated falls (6) or working around the home at a height (5). In terms of height, in those >50 years, there was evidence of both falls from standing (20) and also from greater height (14). In all categories, the surface and posture at impact was not documented. In total, 25% (2) of CSCIs in those aged <30, 37.5% (3) or those aged 30–59 and 27.2% (3) of those aged >60 were associated with alcohol. By mechanism, MVAs were the most common cause of complete injury and of these, car accidents (30) were the predominant mechanism, and also were responsible for the highest proportion of complete to incomplete injuries (44.1%). Falls from height also reported a high complete to incomplete ratio (46.15%). Aside from these three mechanisms, patients were also injured while playing sports like rugby, AFL and skiing (8, 3.4%) and other miscellaneous mechanisms.
the water-related injuries, alcohol or recreational drugs were involved in 42.4% (14) of all cases. In terms of falls (from both standing and from height), alcohol or recreational drugs were at least partially responsible in 26.1% (12) of all incidents. Water-related accidents carried the highest incidence of any of our identified mechanisms.

Blood alcohol levels (BAL) were inconsistently documented throughout the medical notes, but if recorded were generally done so as a percentage of blood. The highest BAL was 0.56%. Recreational and prescription drugs including marijuana, heroin, ecstasy and clonazepam were recorded in association with alcohol in 15.9% (7) of all alcohol-related accidents. Of these marijuana (3) was the most common, and 57.1% (5) were in the 20–29 age group.

Blood Alcohol Levels unavailable for 4 patients because files were at court. Sample size 202 vs 206.

Alcohol and recreational drugs. 21.8% (44) of CSCIs were associated with alcohol and this association was most common in patients in their third decade. In terms of mechanism of alcohol-related accidents, 40.9% (18) were MVAs, 29.5% (14) were water-related cases, and 27.3% (12) falls. Of the water-related injuries, alcohol or recreational drugs were involved in 42.4% (14) of all cases. In terms of falls (from both standing and from height), alcohol or recreational drugs were at least partially responsible in 26.1% (12) of all incidents. Water-related accidents carried the highest incidence of any of our identified mechanisms. Blood alcohol levels (BAL) were inconsistently documented throughout the medical notes, but if recorded were generally done so as a percentage of blood. The highest BAL was 0.56%. Recreational and prescription drugs including marijuana, heroin, ecstasy and clonazepam were recorded in association with alcohol in 15.9% (7) of all alcohol-related accidents. Of these marijuana (3) was the most common, and 57.1% (5) were in the 20–29 age group.

Neurology unavailable for 4 patients because files were at court. Sample size 202 vs 206. Additionally, 2 patients had C-spine and T-spine injury/surgical intervention. Resulting neurology in both was at T7.

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**Figure 4.** The age versus percentage of CSCI according to the top three mechanisms of injury (transport, fall, and water related) of patients treated at the VSCIS from 2000–2009.

**Figure 5.** The season versus number of transport related incidents leading to CSCI that occurred from 2000–2009. The incidents were sub classified into car, motorbike, push bike, pedestrian vs. car and other motor vehicle accidents.
Operatively managed CSCIs are anatomically more unstable than conservatively managed CSCIs, generally due to greater trauma. Thus, we were interested in describing the epidemiology behind these significant injuries at the VSCIS over the last decade. The incidence of CSCI during our study period appears to be stable, with an overall APC of -0.16%. This is in keeping with national Australian spinal cord data. In our cohort, we identified three major mechanisms of CSCI: MVAs, water-related injuries and falls. In all three cohorts, males were over-represented (4:1). This preponderance of males has been documented previously, both in Australia and internationally with ratios reported between 2.5:1 and 5.8:1. As with other international studies, the highest incidence of CSCI was in the 20–29 age group. However, there was a second peak in the 60–69 age group, reflecting a shift in burden of traumatic CSCI from the younger to older age groups. This has implications for future preventative campaigns.

MVAs are a significant contributor to CSCI in Victoria. Much research has been undertaken to reduce road-related mortality and morbidity. Victoria was the first state (worldwide) to implement a universal seat belt law in 1970, which resulted in a decline in mortality by 18%. Additionally, Victoria was the first state in Australia to introduce randomized breath testing, and this demonstrated a 40% reduction in alcohol-related fatalities. We found transport-related incidents comprised 51.5%, in keeping with the thought that MVAs were the most significant factor in cervical injury in Victoria. This was similar to AIHW research, which has found transport-related injuries make up 46% of spinal cord injuries in Australia, and a decade-long international study that found traffic accidents to be the most common cause of cervical spinal fractures. We also found that younger people were more likely to sustain complete CSCI when compared to older patients, perhaps due to their higher incidence in motorized accidents. These accidents were also the dominant cause of CSCI at a level of C3 or higher, suggesting that high level CSCIs were more likely in younger patients. Car accidents, as opposed to motor and push bikes, were disproportionately represented in these injuries. The association between alcohol/illicit drugs and MVAs is well known and our findings were consistent with published data.

In total, it was evident that young males were at greater risk of CSCI via MVAs, and also at greater risk of higher cervical level of injury. A number of international studies have associated intoxicated young men involved in diving or shallow water injuries with CSCI. The most relevant Australian data has found that water-related accidents account for 9% of all cases of spinal cord injury, and that 59% of these cases are below 35 years.

Falls are a leading cause of non-fatal injury. When looking at falls from a standing height, it is known elderly or disabled patients are at higher risk of CSCI. Much research has been undertaken to reduce road-related mortality and morbidity. Victoria was the first state (worldwide) to implement a universal seat belt law in 1970, which resulted in a decline in mortality by 18%. Additionally, Victoria was the first state in Australia to introduce randomized breath testing, and this demonstrated a 40% reduction in alcohol-related fatalities. We found transport-related incidents comprised 51.5%, in keeping with the thought that MVAs were the most significant factor in cervical injury in Victoria. This was similar to AIHW research, which has found transport-related injuries make up 46% of spinal cord injuries in Australia, and a decade-long international study that found traffic accidents to be the most common cause of cervical spinal fractures. We also found that younger people were more likely to sustain complete CSCI when compared to older patients, perhaps due to their higher incidence in motorized accidents. These accidents were also the dominant cause of CSCI at a level of C3 or higher, suggesting that high level CSCIs were more likely in younger patients. Car accidents, as opposed to motor and push bikes, were disproportionately represented in these injuries. The association between alcohol/illicit drugs and MVAs is well known and our findings were consistent with published data. In total, it was evident that young males were at greater risk of CSCI via MVAs, and also at greater risk of higher cervical level of injury.

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being associated with spinal cord injury. Further, it has been hypothesized that the rates of falls-induced CSCI are increasing among older adults. In our data, the major mechanism for injury in those <50 years who fell from height was tripping. This has been previously documented in pediatric populations. It is noteworthy that there was also a peak of CSCIs in our study among patients >50 years and two-thirds of this cohort were male. Mechanistically we found that falls from height around the home contributed to a number of these incidents. Other studies of trauma related to home maintenance have also identified these men as at a high risk of CSCI. Our findings suggest that there is a third, under appreciated high risk group for CSCI; namely, older men partaking in risky behaviors, often associated with home maintenance, that subsequently fall from height.

As in other studies, we found that alcohol played a significant role in all mechanisms of CSCI. However, in our study, it was difficult to quantify levels of alcohol involved, and whether this correlated to increased severity of CSCI. This could be due to the difficulty/lack of obtaining BALs during the initial phase of triage and treatment. Further, we found alcohol was involved in 21.8% of all cases of CSCI, which was in keeping with other Australian studies.

**Limitations**

As with other retrospective studies, collection bias is a major concern in this review. While all attempts were made to gather data appropriately, some charts may have been missed due to legal proceedings or poor coding. Additionally, this study may have been affected by referral bias. Given the size and geography of Victoria, not all CSCIs were presented to our center. Data on patients with CSCI operated on in other hospitals and centers was not accessed and thus our cohort was not inclusive of all CSCI within Victoria (particularly the multi-trauma patients who present to the two adult trauma centers in Victoria). Further, this was a review of patients who received operative management and therefore conservative treatment of CSCI was not included. Finally, the cases reported in this study were limited to surgical cases, and were therefore not a full cross-section of incident data.

**Conclusion**

CSCI in Victoria has been under researched over the last decade. Given the devastating consequences and the financial burden CSCI places on the community, we feel that it should be given greater emphasis in the years ahead. Through our work in the Victorian Spinal Cord Injury Service, we have identified that the incidence of CSCI has remained stable over the last decade and that there are three groups that are particularly at high risk. These are young men involved in MVAs, young intoxicated men around water, and men aged greater than 50 who fall from height. These higher risk groups should be the target of future preventative public awareness campaigns.

**Author Contributions**

Conceived and designed the experiments: GQ. Analyzed the data: SL, NM, RG. Wrote the first draft of the manuscript: SL. Contributed to the writing of the manuscript: NM, RG, GQ. Agree with manuscript results and conclusions: SL, NM, RG, GQ. Jointly developed the structure and arguments for the paper: SL, NM, RG, GQ. Made critical revisions and approved final version: SL, NM, RG, GQ. All authors reviewed and approved of the final manuscript.

**DISCLOSURES AND ETHICS**

As a requirement of publication the authors have provided signed confirmation of their compliance with ethical and legal obligations including but not limited to compliance with ICMJE authorship and competing interests guidelines, that the article is neither under consideration for publication nor published elsewhere, of their compliance with legal and ethical guidelines concerning human and animal research participants (if applicable), and that permission has been obtained for reproduction of any copyrighted material. This article was subject to blind, independent, expert peer review. The reviewers reported no competing interests.

**REFERENCES**