Cervical stenosis in spinal cord injury and disorders

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Context/Objective: The purpose of this study was to characterize etiologies of spinal cord injury and disorders (SCI/D) in persons with and without cervical stenosis/spondylosis (CSS) and to describe clinical characteristics and underlying comorbidities in these populations.

Design and Setting: We reviewed administrative data for 1954 Veterans who had onset of traumatic or non-traumatic tetraplegia during FY 1999–2007. This included 1037 with a diagnosis of CSS at or in the two years prior to SCI onset of SCI/D and 917 without a diagnosis of CSS.

Outcome Measures: Demographics, etiologies of SCI/D and comorbidities by CSS status.

Results: Veterans with SCI/D and CSS were older, more likely to have incomplete injuries and more likely to be Black than those with SCI/D and no CSS. Of patients with traumatic etiologies for SCI, 35.1% had a diagnosis of CSS at the time of or in the 2 years prior to SCI onset. Of those with tetraplegia due to falls, 40.0% had CSS, whereas for other known traumatic etiologies the percentages with CSS were lower: vehicular (25.0%); sports (16.1%); and acts of violence (10.2%). Total comorbidity scores measured by the Charlson co morbidity index and CMS Hierarchical Condition Category (CMS-HCC) were higher in those with CSS and SCI/D compared to those with SCI/D without CSS ($P < 0.0001$ respectively).

Conclusions: CSS is commonly present in patients with new traumatic tetraplegia. Falls are a particularly important potentially modifiable risk for SCI in patients with CSS.

Keywords: Spinal cord injury, Cervical stenosis, Falls, Comorbidities, Registry

Introduction

Cervical stenosis/spondylosis (CSS) is common, occurring in 4.9% of the adult population and 9% of those age seventy years of age and greater.^{1–3} Spinal cord injury (SCI) may occur in persons with cervical stenosis either as a result of progressive, degenerative stenosis with increasing paralysis over time in the absence of trauma⁴ or as a result of an acute cervical trauma which is often relatively mild.⁵ However, there is little information on the characteristics of patients with a SCI who have CSS compared to those without. The primary purpose of this study was to compare the clinical and injury characteristics of Veterans with Spinal

Cord Injury/Disorder (SCI/D) who had a diagnosis of CSS prior to or at the time of the SCI/D compared to those without. The secondary purpose was to describe co morbidities in men and women with SCI/D with and without CSS.

Materials and methods

Participants

We studied all Veterans in the Veterans Affairs (VA) SCD Registry with a history of tetraplegia. The VA SCD Registry is a patient registry that includes Veterans who have received care from the VA SCI/D System of Care.⁶ Date of onset of SCI/D from Registry information and accompanying administrative records were available starting in 1997. To assess the two-year period

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prior to SCI/D for a diagnosis of CSS, we included all veterans with a date of diagnosis/onset of SCI/D that occurred within 1999–2007 and administrative records available at the time of the SCI/D in the analyses.

Date of onset of SCI/D was obtained from VA SCD Registry data; if date was missing the veteran was excluded. Veterans with a history of multiple sclerosis ($n = 193$) and motor neuron disease ($n = 76$) were excluded.

The study was approved by the VA Institutional Review Board, and the study procedures were done in accord with the ethical standards of the VA Institutional Review Boards.

Diagnosis of cervical stenosis/spondylosis (CSS)

The presence of cervical stenosis or cervical spondylosis was obtained from ICD-9 codes and included 723.0 (spinal stenosis in cervical region), 723.7 (ossification of the posterior longitudinal ligament), 722.71 (intervertebral disc disorder with myelopathy cervical region) and 721.0–721.1 (cervical spondylosis). Veterans were stratified into those who had CSS diagnosed at the time of and up to two years prior to their SCI/D and those who never received a diagnosis of CSS in the time period beginning two years prior to SCI through the end of fiscal year (FY) 2009. Veterans with SCI/D who received a CSS diagnosis after their SCI diagnosis were excluded, as it was unclear whether the CSS existed before the SCI/D but was not known or documented or occurred at some point after the SCI/D.

Patient characteristics

Age, sex, race/ethnicity, extent of SCI/D (complete/incomplete/unknown) and etiology of the SCI/D were obtained from VA SCD Registry Data.

Three estimates of comorbidity, including the Charlson Comorbidity Index⁷ the CMS Hierarchical Condition Category (CMS-HCC)⁸ and the Elixhauser Comorbidity Index⁹ were calculated using data from the VHA Medical SAS Inpatient and Outpatient Datasets obtained at the time of and the year prior to diagnosis of the SCI/D. The Charlson Comorbidity Index is calculated based on presence of 17 categories of International Classification of Disease (ICD) diagnoses codes for conditions associated with significant risk of 10-year mortality or health care resource utilization. The CMS-HCC was developed to adjust capitated payment to health care plans using estimates of disease burden, based on presence of coding for 70 disease categories in the prior year. The Elixhauser Comorbidity Index uses 31 categories of conditions to

predict risk of in-hospital mortality, length of stay, and hospital charges.

Statistical analyses

Differences between veterans with and without CSS were examined using Chi-square analysis for differences in categorical variables and *t*-tests for differences in continuous variables. Characteristics of Veterans who had CSS in the two year time period preceding their SCI/D compared to those who had CSS diagnosed at time of SCI/D were also compared.

Results

The cohort included 1954 individuals, 1037 with CSS and 917 without CSS. Those with CSS were significantly older, more likely to be black and less likely to be of other races/ethnicities than those without CSS. Incomplete or extent of injury/disorder unknown was significantly more common in those with CSS compared to those without CSS (Table 1). There were no significant differences in age, race/ethnicity, or extent of injury between those who had CSS diagnosed in the two year time period preceding the SCI compared to those who had SCC diagnosed at the time of the SCI (data not shown).

Etiology of SCI/D differed significantly based on presence or absence of CSS. Of the 917 individuals without CSS, traumatic etiologies accounted for 733 (79.9%), whereas in the 1037 with CSS a traumatic etiology was present in only 396 (38.2%). Falls were the most common causes of SCI/D in the study cohort as a whole, accounting for 26.5% of tetraplegia of any etiology and 42.3% of tetraplegia due to traumatic etiologies. Of those with tetraplegia due to falls, 40.0% had CSS, whereas for other known traumatic etiologies the percentages with CSS were lower: vehicular (25.0%); sports (16.1%); and acts of violence (10.2%) (Table 1).

The mean total Charlson comorbidity index (1.62 ± 1.86 vs. 0.48 ± 1.31) and the CMS-HCC scores (1.17 ± 0.85 vs. 0.53 ± 0.67) were significantly higher in those with CSS compared to those without CSS ($P < 0.0001$ respectively). Adjustment for differences in age group between CSS and non CSS groups did not change the significance of the results of the Charlson index ($P < 0.0001$, data not shown) and age is already included in the calculations for the total score for the CMS-HCC. Similarly, although Elixhauser does not have an overall composite index, all individual comorbidities measured were significantly higher in those with CSS compared to those without, except for the categories of AIDS/HIV, lymphoma, and metastatic cancer which did not differ significantly between the groups ($P \geq 0.379$ respectively, data not shown).

Table 1 Demographics of Study Population by CSS Status

Demographics/ Characteristics	No cervical stenosis or spondylosis n = 917 Mean (Standard Deviation Min- Max) Frequency (%)	Cervical stenosis or spondylosis n = 1037 Mean (Standard Deviation, Min- Max) Frequency (%)	Odds Ratio (95% CI) or P-value
Age at onset of SCI/D	52.84 (16.78, 18–95)	59.8 (11.38, 23–89)	< 0.0001
Sex			
Female	15 (1.64)	28 (2.70)	Reference
Male	902 (98.36)	1009 (97.3)	0.6 (0.32–1.13), 0.109
Race/ethnicity			
White	569 (62.05)	652 (62.87)	Reference
Black	226 (24.65)	339 (32.69)	1.31 (1.07–1.6), 0.009
Other	122 (13.30)	46 (4.44)	0.33 (0.23–0.47), <0.0001
Extent of Injury			
Complete	246 (26.83)	72 (6.94)	Reference
Incomplete	464 (50.60)	816 (78.69)	6.01 (4.51–8), <0.0001
Extent unknown	207 (22.57)	149 (14.37)	2.46 (1.76–3.44), <0.0001
Etiology			
Traumatic etiologies			
Vehicular	297 (32.39)	99 (9.55)	<0.0001
Fall	287 (31.30)	191 (18.42)	<0.0001
Other-Traumatic	58 (6.32)	92 (8.87)	<0.04
Sports Activity	47 (5.13)	9 (0.87)	<0.001
Act of Violence	44 (4.80)	5 (0.48)	<0.0001
Non-Traumatic Etiologies			
Other-Disease	69 (7.52)	274 (26.42)	<0.0001
Infection or Abscess	23 (2.51)	41 (3.95)	<0.001
Arthritic Disease of the	10 (1.09)	228 (21.99)	<0.0001
Spine			
Tumor	10 (1.09)	12 (1.16)	NS
Syringomyelia	1 (0.11)	7 (0.68)	0.009
Unknown			
Etiology missing	71(7.7)	79 (7.6%)	NS

Discussion

Cervical stenosis/spondylosis was an extremely common finding in this cohort of patients with cervical level SCI/D, occurring in over half of all individuals and more than 1/3 of those with a traumatic etiology. These patients were more likely to be older, black and have incomplete injuries compared to those without CSS. Falls were the most common traumatic etiology of the SCI in patients with CSS.

In agreement with our findings that CSS is common in patients with SCI/D, it has been reported that nearly 50% of patients with traumatic central cord syndrome with incomplete SCI/D have congenital or degenerative spinal stenosis and sustained their injuries during hyperextension.¹⁰ In one study of patients with central cord syndrome, 35.7% had pre-existing cervical stenosis.¹¹ Also, the sagittal diameter of the cervical spinal canal has been demonstrated to be significantly smaller in patients with traumatic tetraplegia than in controls, even when patients with preexisting spondylosis are excluded.¹² We are only aware of one report¹³ indicating a significantly lower prevalence of CSS in patients with new, traumatic SCI. In that

study, 4.4% had cervical spondylosis and 3.9% had spinal canal stenosis. However, this was based on a population that included patients with tetraplegia and paraplegia, was younger (mean age 30.7 years) than patients in this study, and did not utilize multiple years of administrative data to ascertain diagnosis of CSS. In persons without SCI/D, CSS is also common, with upwards of 5% of adults in one cadaveric series having cervical stenosis.¹ In the Osteoporotic Fractures in Men Study (mrOS), approximately 4% of men were thought to have generalized spinal stenosis on the basis of questionnaires and clinical examinations.² Thus, our data and others^{1,2,9} suggest that there is a large population of persons with underlying CSS who are risk for SCI/D and better characterization of this population from a public health standpoint is critically important.

In this series of patients with SCI/D, blacks were more likely to have a diagnosis of CSS than were whites. In support of this, one cadaveric study reported that there is variation in the human cervical neural canal by race/ethnicity.¹⁴ In contrast, in another cadaveric series, the presence of cervical stenosis in blacks

compared with whites was not different, although there were few blacks in that study.¹

In this series, among potentially modifiable identified causes of SCI/D (falls, motor vehicle crashes and acts of violence), falls were the most commonly identified cause in those with CSS and were 1.9 times more common than motor vehicle crashes, whereas motor vehicle crashes were the most common cause in those without CSS. Although cervical stenosis is quite common in the general population,^{1,2} the exact numbers of those with cervical stenosis who will develop SCI/D is difficult to know. Identifying which persons with CSS could best benefit from fall prevention strategies in an effort to prevent SCI/D merits further study.

Importantly, co morbidities were significantly more frequent in those with CSS compared to those without. The cause of this difference is not certain. Age is already included in the HCC scoring system, and it is not possible to fully separate the effects of age and co morbidity in this model. However, age is not the only factor explaining differences in co morbidity between our groups since adjustment for age in the Charlson comorbidity scores did not change the significance of the results. It is possible that the underlying causes of the CSS contributed to the comorbidity differences in our study. CSS is most commonly degenerative in nature resulting from osteoarthritis, developmental stenosis, disc hernias, and ossification/calcification of the posterior longitudinal ligament or ligament flavum.^{4,15} Among degenerative causes of CSS, Diffuse Idiopathic Skeletal Hyperostosis (DISH), is associated with underlying medical conditions including diabetes, hypertension and the metabolic syndrome.¹⁶ Additionally, activation of a proinflammatory marker, nuclear factor kappaB, may be involved in the ossification of spinal ligaments.¹⁷ Nuclear factor kappaB is involved in the pathogenesis of a number of diseases including cardiovascular disease¹⁸ cancer¹⁹ and in cell death processes in general.²⁰ Other nondegenerative etiologies which are themselves associated with substantial morbidity including rheumatoid arthritis²¹ may also cause CSS. Alternatively, these data may reflect that a larger number of our CSS veterans had a non-traumatic cause of SCI, compared with a traumatic cause of their SCI. Non-traumatic SCIs have been reported to have a larger number of comorbidities.²²

This study has a number of important limitations. First, it was limited to veterans; whether these results are applicable to the whole population of persons with SCI/D and CSS is not known. There were few women included in our registry data. The diagnosis of CSS was based on ICD-9 codes at the time of our study,

and we have no information on how the CSS was confirmed. CSS was likely present at the time of SCI/D onset in additional patients who did not receive a first ICD-9 code for CSS until a subsequent episode of care, as all such patients were excluded from our analyses due to uncertainty about actual CSS status at time of SCI/D onset. We did not have further information on the etiologies of SCI/D, in particular, the circumstances regarding the falls.

Conclusion

In conclusion, more than half of patients with tetraplegia of any etiology (traumatic or non-traumatic) have CSS present at the time of onset, and more than one third of patients with traumatic etiologies have CSS. Falls are the most common identified potentially modifiable risk factor for SCI/D in those with CSS. Persons with SCI/D and CSS have higher comorbidities compared to those with SCI/D without CSS. Further work is needed to determine the utility of fall prevention strategies at reducing rates of SCI/D in selected patients with CSS.

Acknowledgments

This work was funded by Supported by the Department of Veterans Affairs, Veterans Health Administration, Health Services Research and Development (grant no. IIR 08-033). The contents do not represent the views of the Department of Veterans Affairs or the United States Government.

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