Spinal Cord (2015) 53, 668–672

www.nature.com/sc

ORIGINAL ARTICLE

Assessment of clinical adherence to the international autonomic standards following spinal cord injury

JW Squair[1,7], G le Nobel[2,7], VK Noonan[3], G Raina[4] and AV Krassioukov[1,5,6]

Study design: Retrospective chart analysis.
Objectives: To investigate the use of the International Autonomic Standards (IAS, 2009 edition) for classification of remaining autonomic function following spinal cord injury (SCI) over a 1-year period in a rehabilitation center, to determine clinical adherence to use of the IAS, and to examine the most common autonomic dysfunctions, as determined by using the IAS.
Setting: Tertiary rehabilitation hospital.
Methods: A retrospective study was conducted on the use of the IAS at admission and discharge over a 1-year period on patients admitted to an in-patient SCI unit in a tertiary rehabilitation center. We examined the consistency of the form completion, as well as the completion of separate components of the forms. Finally, we examined the prevalence of each autonomic impairment.
Results: A total of 70 patients were admitted to the unit. The clinical adherence to the IAS was lower than the International Standards for Neurological Classification of SCI (ISNCSCI) at both admission (63% and 93%, respectively) and discharge (39% and 78%, respectively). Blood pressure dysfunction was most common among the general autonomic function disorders. However, urinary, bowel and sexual dysfunctions were present in almost all individuals with acute SCI.
Conclusion: The IAS is in the initial stages of being incorporated into routine admission and discharge clinical examinations of individuals with SCI. The current results suggest that the clinical adherence to the IAS is low; however, it is expected that increased education, experience, and accumulating evidence for the IAS will improve its use.
Spinal Cord (2015) **53,** 668–672; doi:10.1038/sc.2015.54; published online 31 March 2015

INTRODUCTION

Historically, the focus in the assessment of patients with spinal cord injury (SCI) has been on the evaluation of motor and sensory functions. The importance of a standardized method of assessing motor and sensory function following SCI was recognized, and the initial American Spinal Cord Injury Association (ASIA) neurological examination was adopted in 1982.[1] The ASIA neurological examination has since undergone revision and improvement. In 1992, the ASIA neurological examination was adopted by the International Spinal Cord Society and was renamed the International Standards for Neurological Classification of SCI (ISNCSCI). The latest revision of the ISNCSCI was carried out in 2011.[2]

In addition to the motor and sensory dysfunctions in patients with SCI, autonomic dysfunctions are common and can result in various secondary conditions that contribute significantly to morbidity and mortality in both the acute and chronic phases. SCI often results in damage to descending autonomic pathways, altering the parasympathetic and sympathetic control of almost every body system, including the heart, blood vessels, respiratory tract, sweat glands, bowel, urinary bladder and sexual organs.[3,4] For example, in both the acute and chronic phases, impairment of the cardiovascular system often leads to significant blood pressure dysregulation, which is thought to contribute to a threefold increased risk of cardiovascular disease,[5] the SCI population's leading cause of mortality.[6] Unfortunately, dysfunctions in the autonomic system are not adequately accounted for by a standard neurological assessment as there is a limited understanding of the relationship between the level and completeness of SCI and autonomic dysfunction.[7] Moreover, examination of the autonomic nervous system is difficult because of its complexity and involvement in the control of almost every body system.[3] Although a battery of possible tests exist to assess autonomic dysfunctions, experience in the evaluation of autonomic dysfunctions is very limited among clinicians and current evaluation techniques lack uniform operational definitions.[7] Due to the severity of possible complications associated with autonomic dysfunction and the complexity of autonomic neuroanatomy, a standardized assessment of the remaining autonomic functions was needed.

To this end, in 2008, the International Autonomic Standards (IAS) were developed through an experts' opinion consensus,[8,9] underwent revisions and improvement in 2012[10] and were recommended for clinical use. The IAS were developed as a standardized method for assessing autonomic function, communicating the effects of SCI on

[1]International Collaboration on Repair Discoveries (ICORD), Faculty of Medicine, University of British Columbia, Vancouver, British Columbia, Canada; [2]Department of Medicine, University of Toronto, Toronto, Ontario, Canada; [3]Rick Hansen Institute, Vancouver, British Columbia, Canada; [4]Department of Biology, Queens University, Kingston, Ontario, Canada; [5]Department of Medicine, Division of Physical Medicine and Rehabilitation, University of British Columbia, Vancouver, British Columbia, Canada and [6]GF Strong Rehabilitation Centre, Vancouver Health Authority, Vancouver, British Columbia, Canada
[7]These authors contributed equally to this work.
Correspondence: Dr A Krassioukov, International Collaboration on Repair Discoveries (ICORD), Faculty of Medicine, University of British Columbia, 818 West 10th Avenue, Vancouver, British Columbia, Canada V5Z 1M9.
E-mail: krassioukov@icord.org
Received 18 November 2014; revised 12 January 2015; accepted 15 January 2015; published online 31 March 2015

cardiovascular, bronchopulmonary, sudomotor, bladder, bowel and sexual function following injury, and to follow the recovery of these functions during rehabilitation. The 2009 IAS is divided into three sections concerned with the evaluation of general autonomic functions, lower urinary tract, bowel and sexual functions and urodynamic functions. The general autonomic function section documents cardiac dysrythmias, blood pressure abnormalities, sudomotor dysfunctions, temperature dysregulation and control of the bronchopulmonary system. The lower urinary tract, bowel and sexual function section documents dysfunctions in these three systems; and the urodynamic section documents bladder sensation during filling, detrusor activity and sphincter control. However, to date there has been no assessment of the clinical adherence to the use of the IAS.

Therefore, the purpose of this study was to examine the use of the IAS over a 1-year period in a rehabilitation center. We conducted a retrospective chart analysis of all newly admitted individuals with SCI to determine clinical adherence to use of the IAS and to examine the most common autonomic dysfunctions, as determined using the IAS.

MATERIALS AND METHODS

The ethics protocol for this study was approved by the University of British Columbia. Before the study, an in-service educational seminar was conducted with all staff physicians ($n=5$) responsible for the admission and evaluation of SCI patients at the rehabilitation hospital to provide information and training on the use of the IAS form and to clarify the importance of an autonomic assessment. The charts for individuals admitted to the rehabilitation hospital with SCI over a 1-year period were then obtained. From each chart, admission and discharge ISNCSCI and IAS forms were obtained, as well as the date of birth and gender of the patient, date of admission and discharge from the rehabilitation hospital and the cause and date of the patient's SCI.

Data were then compiled and entered into a database for further analyses. Analyses of the IAS forms was conducted separately for patients with traumatic and nontraumatic SCI. In addition, all analyses were conducted by classifying injuries as cervical (C1–C8 levels), high-thoracic (T1–T5) and low-thoracic/lumbar (T6 or below). In the analysis of the IAS forms, we examined the consistency of the form completion, as well as the completion of separate components of the forms. Finally, we examined the prevalence of each autonomic impairment, as assessed by the IAS.

RESULTS

Patient demographics

A total of 70 charts were examined. There were a total of 52 individuals with traumatic SCI and 18 individuals with nontraumatic SCI. Of those with traumatic SCI, there were a total of 46 (88%) males and 6 (12%) females. The average age of patients admitted for traumatic SCI was 53 ± 17 years. When stratified by the lesion level there were a total of 37 (71%) patients with cervical SCI, 5 (10%) with high-thoracic SCI and 10 (19%) with low-thoracic/lumbar SCI. From admission to discharge one patient had their neurological level of injury change from high-thoracic to low-thoracic/lumbar, and two patients moved from a complete to an incomplete injury. The most common causes of traumatic SCI were motor vehicle accidents (17, 32%), followed by falls (16, 31%), recreation accidents (15, 29%), work-related accidents (2, 4%) and violence-related accidents (2, 4%).

For individuals admitted with nontraumatic SCI, there were a total of 14 males (78%) and 4 females (22%). The average age of patients admitted for nontraumatic SCI was 64 ± 15 years. When stratified by group there were a total of seven (39%) patients with cervical SCI, five (28%) with high-thoracic SCI and six (33%) with low-thoracic/lumbar SCI. From admission to discharge one patient moved from a high-thoracic classification to a low-thoracic/lumbar classification. The most common causes of injury were cancer (7, 39%) and vascular pathology (5, 28%).

Clinical completion of the IAS

The clinical completion of the IAS was, on average, lower compared with the ISNCSCI at both admission (63% and 93%, respectively) and discharge (39% and 78%, respectively) (Table 1). When broken down by section, the IAS was, in general, filled out consistently with section completions ranging from 84% (bowel) to 93% (pulmonary system) (Table 2). However, the sexual function assessment was performed in only 36% and 56% of patients at admission and discharge, respectively (Table 2). The urodynamic evaluation was not filled out for any of the 70 patients.

Prevalence of autonomic dysfunctions

Upon examination of the general autonomic function section of the IAS, autonomic dysfunction in the control of blood pressure was most

Table 1 Adherence to completion of clinical assessments from admission and to discharge

Lesion level cohort	*IAS*			*ISNCSCI*		
	Acute traumatic SCI (n = 52)	*Acute nontraumatic SCI (n = 18)*	*Average (n = 70)*	*Acute traumatic SCI (n = 52)*	*Acute nontraumatic SCI (n = 18)*	*Average (n = 70)*
Admission						
Cervical SCI	54% (37)	100% (7)	61% (44)	95% (37)	71% (7)	91% (44)
High-thoracic SCI	80% (5)	40% (5)	60% (10)	80% (5)	100% (5)	90% (10)
Low thoracic/lumbar SCI	60% (10)	83% (6)	69% (16)	100% (10)	100% (6)	100% (16)
			63% (70)			**93% (70)**
Discharge						
Cervical SCI	39% (36)	43% (7)	40% (434)	83% (36)	71% (7)	81% (44)
High-thoracic SCI	80% (5)	0% (4)	44% (9)	80% (5)	50% (4)	67% (9)
Low thoracic/lumbar SCI	30% (10)	43% (7)	35% (17)	90% (10)	57% (7)	76% (17)
			39% (69)			**78% (70)**

Abbreviations: IAS, International Autonomic Standards; ISNCSCI, International Standards for Neurological Classification of Spinal Cord Injury; SCI, spinal cord injury.
The percentage of patients assessed in each cell is presented on the left in each cell. The total number of patients assessed in each category is presented in parentheses. Overall averages for each section are presented in bold. Note: one patient had no neurological function assessed at discharge and therefore was excluded.

Table 2 A breakdown by section of the IAS highlights clinician completion of adherence to individual aspects of the assessment at admission and discharge in persons with traumatic and nontraumatic SCI

	Acute traumatic SCI			*Acute nontraumatic SCI*			*Average*
	Cervical	*High-thoracic*	*Low thoracic/ lumbar*	*Cervical*	*High-thoracic*	*Low thoracic/ lumbar*	
Admission, n *(completed/total)*	*20/37*	*4/5*	*6/10*	*7/36*	*2/5*	*5/6*	*44/70*
Autonomic control of the heart	75%	100%	100%	86%	100%	100%	**86%**
Autonomic control of BP	85%	100%	100%	100%	100%	100%	**93%**
Autonomic control of sweating	90%	75%	100%	86%	50%	100%	**87%**
Temperature regulations	80%	100%	100%	100%	50%	100%	**87%**
Autonomic and somatic control of bronchopulmonary system	85%	100%	100%	100%	50%	100%	**93%**
Lower urinary tract function	85%	100%	83%	86%	50%	100%	**86%**
Bowel function	95%	75%	83%	86%	50%	60%	**84%**
Sexual function	45%	50%	33%	29%	0%	20%	**36%**
Discharge, n *(completed/total)*	*14/36*	*4/5*	*3/10*	*3/7*	*0/4*	*3/7*	*26/69*
Autonomic control of the heart	86%	100%	67%	100%	—	100%	**89%**
Autonomic control of BP	93%	100%	67%	100%	—	100%	**93%**
Autonomic control of sweating	79%	100%	67%	100%	—	100%	**85%**
Temperature regulations	93%	100%	67%	100%	—	100%	**93%**
Autonomic and somatic control of bronchopulmonary system	93%	100%	67%	100%	—	100%	**93%**
Lower urinary tract function	93%	100%	100%	100%	—	100%	**97%**
Bowel function	86%	100%	100%	100%	—	100%	**93%**
Sexual function	46%	75%	33%	100%	—	33%	**56%**

Abbreviations: BP, blood pressure; SCI, spinal cord injury.
The number of participants in each category (that is, acute traumatic SCI, cervical) is determined by the number of participants with at least one part of the IAS completed or the IAS partially or completely filled in at admission and discharge, respectively (see Table 1). Participants with no IAS form were excluded to avoid biasing the results. Overall averages for each section are presented in bold on the right. Note: the number of patients at admission and discharge may differ.

common. At admission, orthostatic hypotension was the most common dysfunction (29%), followed by resting hypotension (20%). However, there was at least one patient with documented autonomic dysfunction in every category (Table 3). At discharge, the pattern of dysfunction was similar to admission with blood pressure abnormalities being most common. However, the overall prevalence of autonomic dysfunction was lower and, in particular, resting hypotension was completely abolished, as were tachycardia and hyperhydrosis below the level of the lesion (Table 3). When considering lower urinary tract, bowel and sexual function, dysfunction was present in a large number of patients at both admission and discharge (Table 3). In fact, sexual dysfunction was present in 100% of patients who had the sexual function aspect of the IAS completed at discharge (Table 3).

DISCUSSION

In this study, we examined the use of the IAS and ISNCSCI examination forms for patients admitted with SCI to a tertiary rehabilitation hospital. The IAS were partially or completely filled out overall in 63% and 39% of individuals with SCI at admission and discharge, respectively. These numbers are in stark contrast to the 93 and 78% of individuals who were assessed using the ISNCSCI. Considering the large number of patients who experience autonomic dysfunctions, it is important that the clinical use of the IAS increases. It is likely that the perceived clinical utility of the ISNCSCI compared with the IAS among clinicians partially explains the discrepancies in their use. Furthermore, the low completion rate of the IAS may also be due to inexperience and a lack of current data on its clinical utility.

The ISNCSCI was originally conceived in 1982 and has since seen seven revisions, most recently in 2011.[2] The information garnered from this assessment has been validated, examined for its clinical use and relationship to physiological complications and is currently used in the classification and stratification of injury groups in large epidemiological studies.[11] Conversely, the IAS is relatively new, being conceived in 2009 and having only one revision since then in 2012.[10] In fact, our study is the first to examine its use in a clinical setting. Therefore, although we suggest avenues to increase the IAS's clinical use, it is not surprising it is currently not used to the same extent as the ISNCSCI. In addition to the act of time that will facilitate the use of the IAS in clinical settings, it is our prerogative to provide resources to encourage and educate clinicians on its use. Similar to the InSTeP program put out jointly by ASIA and International Spinal Cord Society, a web-based education system (ASTeP—Autonomic Standards Training eProgram) has now been developed to educate clinicians on the use of the IAS. We strongly believe that the addition of this resource will provide clinicians the information they need to feel comfortable in the delivery of this crucial assessment (www.ASIAlearningcenter.com).

Through examination of the completion rates for each individual section of the IAS, we were able to highlight shortcomings in the current use of the IAS. In patients with whom IAS forms had been filled out, most sections of the assessment were consistently filled in by clinicians (Table 2). Sexual function was the main exception to this, with a completion rate of only 30% of forms. This finding is not surprising given the fact that these patients were admitted acutely and, as such, would not have ample opportunity to determine their sexual function within a hospital setting. Although information on the evolution of sexual function from the acute to chronic settings may be useful in evaluating autonomic improvement, it is unlikely that this information will be garnered in an acute setting, and we therefore recommend that clinicians standardize their response to this section of the IAS with a 'not assessable'.

Table 3 Prevalence of autonomic dysfunctions in persons with SCI as assessed using the IAS.

	Acute traumatic SCI			*Acute nontraumatic SCI*			*Average*
	Cervical	*High-thoracic*	*Low thoracic/ lumbar*	*Cervical*	*High-thoracic*	*Low thoracic/ lumbar*	
Admission, n	*37*	*5*	*10*	*7*	*5*	*6*	*70*
Bradycardia	27% (15)	0% (4)	17% (6)	17% (6)	0% (2)	0% (5)	**16% (38)**
Tachycardia	0% (15)	0% (4)	17% (6)	0% (6)	0% (2)	0% (5)	**3% (38)**
Other dysrhythmias	7% (15)	0% (4)	0% (6)	0% (6)	0% (2)	0% (5)	**3% (38)**
Resting systolic BP <90 mm Hg	41% (17)	0% (4)	0% (6)	14% (7)	0% (2)	0% (5)	**20% (41)**
Orthostatic hypotension	47% (17)	25% (4)	17% (6)	29% (7)	0% (2)	0% (5)	**29% (41)**
Autonomic dysreflexia	24% (17)	0% (4)	0% (6)	14% (7)	0% (2)	0% (5)	**12% (41)**
Hyperhydrosis above lesion	28% (18)	0% (3)	0% (6)	0% (6)	0% (1)	0% (5)	**13% (39)**
Hyperhydrosis below lesion	6% (18)	0% (3)	0% (6)	17% (6)	0% (1)	0% (5)	**5% (39)**
Hypohydrosis below lesion	24% (18)	0% (3)	0% (6)	0% (6)	0% (1)	0% (5)	**11% (39)**
Hyperthermia	25% (16)	25% (4)	0% (6)	0% (7)	0% (1)	0% (5)	**13% (39)**
Hypothermia	25% (16)	0% (4)	0% (6)	0% (7)	0% (1)	0% (5)	**10% (39)**
Requiring full ventilator support	6%(17)	0% (4)	0% (6)	14% (7)	0% (1)	0% (5)	**5% (40)**
Requiring partial vent support	6% (17)	0% (4)	0% (6)	0% (7)	50% (2)	0% (5)	**4% (40)**
Impaired—no vent support	12% (17)	0% (4)	0% (6)	0% (7)	0% (1)	0% 5)	**5% (40)**
Urinary tract dysfunction	88% (17)	100% (4)	100% (5)	83% (6)	100% (1)	100% (5)	**92% (38)**
Bowel dysfunction	95% (19)	100% (3)	100% (5)	67% (6)	100% (1)	100% (3)	**92% (37)**
Sexual dysfunction	88% (9)	100% (3)	100% (2)	100% (2)	—	100% (1)	**93% (16)**
Discharge, n	*36*	*5*	*10*	*7*	*4*	*7*	*69*
Bradycardia	8% (12)	0% (4)	0% (2)	0% (3)	—	0% (3)	**4% (24)**
Tachycardia	0% (12)	0% (4)	0% (2)	0% (3)	—	0% (3)	**0% (24)**
Other dysrhythmias	8% (12)	0% (4)	0% (2)	0% (3)	—	0% (3)	**4% (24)**
Resting systolic BP <90 mm Hg	0% (13)	0% (4)	0% (2)	0% (3)	—	0% (3)	**0% (25)**
Orthostatic hypotension	38% (13)	0% (4)	0% (2)	0% (3)	—	0% (3)	**20% (25)**
Autonomic dysreflexia	23% (13)	0% (4)	0% (2)	50% (3)	—	0% (3)	**18% (25)**
Hyperhydrosis above lesion	9% (11)	0% (4)	0%(2)	50% (3)	—	0% (3)	**11% (23)**
Hyperhydrosis below lesion	0% (11)	0% (4)	0% (2)	0% (3)	—	0% (3)	**0% (23)**
Hypohydrosis below lesion	9% (11)	0% (4)	0% (2)	0% (3)	—	0% (3)	**4% (23)**
Hyperthermia	15% (13)	0% (4)	0% (2)	0% (3)	—	0% (3)	**8% (25)**
Hypothermia	23% (13)	0% (4)	0% (2)	0% (3)	—	0% (3)	**12% (25)**
Requiring full ventilator support	15% (13)	0% (4)	0% (2)	0% (3)	—	0% (3)	**8% (25)**
Requiring partial vent support	0% (13)	0% (4)	0% (2)	0%(3)	—	0% (3)	**0% (25)**
Impaired—no vent support	31% (13)	25% (4)	33% (2)	33% (3)	—	0% (3)	**27% (25)**
Urinary tract dysfunction	84% (13)	100% (4)	100% (3)	100% (3)	—	100% (3)	**92% (26)**
Bowel dysfunction	92% (12)	100% (4)	100% (3)	100% (3)	—	100% (3)	**96% (25)**
Sexual dysfunction	100% (7)	100% (3)	100% (1)	100% (3)	—	100% (3)	**100% (15)**

Abbreviations: BP, blood pressure, IAS, International Autonomic Standards; SCI, spinal cord injury.
The percentage of patients presenting with each autonomic dysfunction is presented. The *n*-value of each cell, located in parentheses on the right of each cell, is determined by the number of participants with the respective section of the IAS (that is, autonomic control of the heart) completed for each patient group at admission and discharge, respectively (see Table 2). In addition, the total number of patients is presented at the top of each respective section. Overall averages for each section are presented in bold on the right. Note: the IAS was not completed on any patients with high-thoracic nontraumatic SCI.

Another major finding from our analyses of the IAS form completion rates was that, at our rehabilitation hospital, the urodynamic portion of the IAS was not filled out in any patients. This was due to the fact that the first urodynamic evaluation is typically performed between 6 and 12 months following the onset of injury. As such, the urodynamic portion of the IAS was never actually completed, as this assessment is outside the time frame of hospitalization for initial rehabilitation following SCI. Through communication with colleagues across North America, we learned that this logistical problem pervaded through other institutions, and thus this finding was reported to the joint ASIA/International Spinal Cord Society Autonomic Standards Committee in conjunction with a recommendation to revise this portion of the IAS upon the next addition. The IAS have since been revised[10], renamed to the International Standards to document remaining Autonomic Function after SCI and the urodynamic portion of the assessment has been removed. However, the committee has recommended to use the Urodynamic Basic Data Set Form when the individual undergoes the urodynamic assessment to record and document these parameters.[12]

Among patients with completed or partially completed IAS forms at admission, the vast majority of patients with traumatic and nontraumatic SCI had documented autonomic dysfunctions. Considering that the leading cause of mortality in the SCI population is cardiovascular disease,[5] it is paramount to ensure the IAS results are consistent with neurophysiogical-based predictions and previous epidemiological data. Examination of the IAS forms showed that blood pressure abnormalities were found to occur in accordance with previous large-scale studies.[5] As is expected, on the basis of the neuroanatomical layout of

the autonomic nervous system, we observed autonomic dysreflexia primarily in individuals with cervical SCI.[13] The frequency distribution of autonomic dysreflexia is congruent with the fact that both severity and level of SCI are predisposing factors for autonomic dysreflexia.[13,14] The absence of autonomic dysreflexia in patients with low-thoracic/lumbar SCI is consistent with previous observations that an injury at T6 or above is essential for autonomic dysreflexia.[15,16] Furthermore, among patients admitted with acute traumatic SCI, orthostatic hypotension was also observed more frequently in individuals with cervical injuries. The increasing incidence of orthostatic hypotension in individuals with cervical SCI as compared with high-thoracic and low-thoracic/lumbar studies is in agreement with previous studies and is expected based on the level of injury.[17,18] Although these results provide some indication that the IAS provides information that is in line with previous epidemiological data and anatomical predictions, we must acknowledge that interpretation of these results is limited. This study was conducted retrospectively on patients from only one rehabilitation center, many of whom did not have a fully completed IAS form. This limits our conclusions about the prevalence of autonomic dysfunctions, and, although we can observe a general decline in dysfunctions from admission to discharge, we are limited in our ability to use the IAS to track autonomic dysfunction over time within a patient. Further studies examining new iterations of the IAS might attempt a multisite retrospective analysis to provide information on a large number of patients while also monitoring form completion throughout the study and thereby provide results that can be better extrapolated to the SCI population.

CONCLUSION

In this study, we saw that the IAS is still in the initial stages of being incorporated into routine admission and discharge examinations in the setting of a tertiary care rehabilitation hospital. Moving forward, we expect that the IAS will be a standard admission and discharge assessment for persons with SCI. For example, Accreditation Canada has now made the International Standards to document remaining Autonomic Function after SCI a mandatory assessment for accredited hospitals across Canada. Although the rate at which the IAS forms were filled out in this sample was low, this is likely attributable to inexperience using the IAS, as well as the current lack of evidence to support its use. Use of the IAS is expected to increase worldwide as experience in the use of the Standards increases and studies regarding its use accumulate. In fact, this study presents an assessment of the use of the IAS in its first version after development through expert consensus. As was the case with the standard neurological examination, it is expected that the IAS will undergo several iterations of revision and validation; however, it appears that this early version of the IAS is consistent with epidemiological data in assessing autonomic dysfunctions. With each iteration, studies into the use of the IAS will be needed to assess the use of the Standards. We encourage clinicians to educate themselves on the use of the IAS through the online modules and to introduce its use into standard clinical practice.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

We thank the physicians and patients of the SCI program at GF Strong Hospital who participated in this project. This work was supported by funding to the laboratory of AVK from the Canadian Foundation for Innovation, BC Knowledge Translation Foundation, the Canadian Institute for Health Research and the Craig Neilsen Foundation. VN is supported as an employee of the Rick Hansen Institute.

1 American Spinal Cord Injury Association [ASIA]. *Standards for Neurological Classification of Spinal Injured Patients*. ASIA: Chicago, 1982.
2 Kirshblum SC, Burns SP, Biering-Sorensen F, Donovan W, Graves DE, Jha A *et al*. International standards for neurological classification of spinal cord injury (Revised 2011). *J Spinal Cord Med* 2011; **34**: 535.
3 Krassioukov A, Weaver L. Anatomy of the autonomic nervous system. *J Phys Med Rehabil* 1996; **10**: 1–14.
4 Furlan JC, Fehlings MG, Shannon P, Norenberg MD, Krassioukov AV. Descending vasomotor pathways in humans: correlation between axonal preservation and cardiovascular dysfunction after spinal cord injury. *J Neurotrauma* 2003; **20**: 1351–1363.
5 Cragg JJ, Noonan VK, Krassioukov A, Borisoff J. Cardiovascular disease and spinal cord injury Results from a national population health survey. *Neurology* 2013; **81**: 723–728.
6 De Vivo MJ, Stuart Krause J, Lammertse DP. Recent trends in mortality and causes of death among persons with spinal cord injury. *Arch Phys Med Rehabil* 1999; **80**: 1411–1419.
7 Testing the autonomic nervous system. Seminars in neurology. 2003, Thieme Medical Publishers, Inc.: New York, NY, USA.
8 Alexander M, Biering-Sorensen F, Bodner D, Brackett N, Cardenas D, Charlifue S *et al*. International standards to document remaining autonomic function after spinal cord injury. *Spinal Cord* 2009; **47**: 36–43.
9 Krassioukov A, Karlsson AK, Wecht JM, Wuermser LA, Mathias CJ, Marino RJ. Assessment of autonomic dysfunction following spinal cord injury: rationale for additions to International Standards for Neurological Assessment. *J Rehabil Res Dev* 2006; **44**: 103–112.
10 Krassioukov A, Biering-Sørensen F, Donovan W, Kennelly M, Kirshblum S, Krogh K *et al*. International standards to document remaining autonomic function after spinal cord injury. *J Spinal Cord Med* 2012; **35**: 201–210.
11 Lenehan B, Street J, Kwon BK, Noonan V, Zhang H, Fisher CG *et al*. The epidemiology of traumatic spinal cord injury in British Columbia, Canada. *Spine* 2012; **37**: 321–329.
12 Biering-Sørensen F, Craggs M, Kennelly M, Schick E, Wyndaele J. International urodynamic basic spinal cord injury data set. *Spinal Cord* 2008; **46**: 513–516.
13 Curt A, Nitsche B, Rodic B, Schurch B, Dietz V. Assessment of autonomic dysreflexia in patients with spinal cord injury. *J Neurol Neurosurg Psychiatry* 1997; **62**: 473–477.
14 Mathias C, Frankel H. The cardiovascular system in tetraplegia and paraplegia. *Handb Clin Neurol* 1992; **17**: 435–456.
15 Krassioukov A, Furlan JC, Fehlings MG. Autonomic dysreflexia in acute spinal cord injury: an under-recognized clinical entity. *J Neurotrauma* 2003; **20**: 707–716.
16 Mathias CJ, Frankel H. Autonomic disturbances in spinal cord lesions. In: Bannister R, Mathias CJ (eds). *Autonomic Failure*. 3rd edn Oxford University Press: Oxford, UK, 839–881, 1992.
17 Claydon V, Steeves J, Krassioukov A. Orthostatic hypotension following spinal cord injury: understanding clinical pathophysiology. *Spinal Cord* 2005; **44**: 341–351.
18 Claydon VE, Krassioukov A. Orthostatic hypotension and autonomic pathways after spinal cord injury. *J Neurotrauma* 2006; **23**: 1713–1725.