

## INTERNATIONAL SPINAL CORD INJURY DATA SETS

### CARDIOVASCULAR FUNCTION BASIC DATA SET – COMMENTS

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Cardiovascular abnormalities have been well documented in humans following spinal cord lesions.<sup>1,2</sup> The recognition and management of these cardiovascular dysfunctions following spinal cord injury (SCI) represent challenging clinical issues. Moreover, cardiovascular disorders in the acute and chronic stages of SCI are among the most common causes of death in individuals with SCI.<sup>3-5</sup> Unfortunately, little attention has been paid to the documentation of these dysfunctions in individuals with spinal cord lesions.<sup>6</sup>

In accordance with the aims of the International Spinal Cord Injury Data Sets<sup>7</sup> the aim of the Cardiovascular Function Basic Data Set for Spinal Cord Injury is to standardize the collection and reporting of a minimal amount of information on cardiovascular function in daily practice. Furthermore, the International Cardiovascular Function Basic SCI Data Set makes it possible to evaluate and compare results from various published studies on cardiovascular dysfunction after SCI.

The Cardiovascular Function Basic SCI Data Set is applicable to adults with traumatic or non-traumatic supraconal, conal or cauda equina lesions. To ensure that data is standardized, each variable and each response category within variables have been specifically defined.

The Cardiovascular Function Basic SCI Data Set will be used in connection with the background information within the International SCI Core Data Set.<sup>8</sup> The SCI Core Data Set documents the level, completeness and time post-spinal cord lesion which play an important role on cardiovascular outcomes following injury.

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VARIABLE NAME: Date of data collection

DESCRIPTION: This variable documents the date of data collection

CODES: YYYYMMDD

COMMENTS: As the collection of data on cardiovascular functions may be conducted at any time following SCI, the date of data collection is imperative to compute the length of time since the spinal cord lesion occurred and to identify data collected in relation to other data collected on the same individual at various time points.

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VARIABLE NAME: Cardiovascular function before spinal cord lesion (collected once):

DESCRIPTION: This variable documents the history of cardiovascular function present prior to the spinal cord lesion and should be collected only once.

CODES: Cardiac pacemaker, date last inserted YYYYMMDD  
Cardiac surgery, specify \_\_\_\_\_, date last performed YYYYMMDD  
Other cardiac disorders, specify \_\_\_\_\_  
Hypertension  
Hypotension  
Orthostatic hypotension  
Deep vein thrombosis  
Neuropathy (alcoholic, diabetic, and others)  
Other, specify \_\_\_\_\_  
Unknown

COMMENTS: These codes include conditions present prior to the spinal cord lesion, which may influence the outcomes related to the cardiovascular functions.  
Abnormal heart rates and rhythms are commonly present following a spinal cord lesion.<sup>9,10</sup> Presence of a *cardiac pacemaker, previous surgeries* (e.g. ablation of ectopic foci) or other conditions (e.g. pre-existing atrial fibrillation, myocardial infarction, or congestive heart failure) could influence these parameters.<sup>11</sup>  
Altered autonomic control routinely leads to instability of blood pressure following spinal cord lesions. Hypotension is common in acute and chronic spinal cord lesions. In addition, intermittent hypertension can be associated with noxious or non-noxious stimuli and resultant autonomic dysreflexia. Preexisting abnormalities of blood pressure can influence these changes.  
*Hypertension:* (arterial blood pressure >140/90 mmHg)<sup>12</sup>

*Hypotension:* (systolic arterial blood pressure < 90 mmHg)  
*Orthostatic hypotension:* Symptomatic or asymptomatic decrease in blood pressure usually exceeding 20 mmHg systolic or 10 mmHg diastolic on moving from the supine to an upright position.  
<sup>13</sup>

*Deep vein thrombosis:* Thrombosis of the deep veins of the legs, pelvis or arms, due to coagulopathy, stasis, or endothelial injury  
<sup>14</sup>

Pre-existing *neuropathies* (e.g. diabetic or alcoholic neuropathy) and *other conditions* associated with autonomic dysfunctions (e.g. Parkinsons disease, multiple sclerosis, traumatic brain injury) can affect altered cardiovascular functions post spinal cord lesion, and should therefore be included.  
<sup>13,15-17</sup>

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VARIABLE NAME: Events related to cardiovascular function after spinal cord lesion:

DESCRIPTION: These variable documents events related to cardiovascular functions that occur at any time after the spinal cord lesion.

CODES: Cardiac pacemaker, date YYYYMMDD  
Myocardial infarction, date YYYYMMDD  
Stroke date, YYYYMMDD  
Deep vein thrombosis date, YYYYMMDD  
Other, specify \_\_\_\_\_, date YYYYMMDD  
Unknown

COMMENTS: These time-limited cardiovascular events with long-term sequelae should have their dates documented to be able to compute the time since injury and to identify the data collected in relation to various time points.

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VARIABLE NAME: Cardiovascular function history after the spinal cord lesion within the last three months:

DESCRIPTION: This variable documents any cardiovascular function that occurred after the spinal cord lesion (within three months).

CODES: Cardiac conditions, specify \_\_\_\_\_  
Orthostatic hypotension  
Dependent oedema  
Hypertension  
Autonomic dysreflexia  
Other, specify \_\_\_\_\_  
Unknown

COMMENTS: *Cardiac conditions:* Subjective symptoms related to the heart that occur post-spinal cord lesion should be documented (e.g. abnormal heart rates/rhythm, angina, palpitation etc.).

*Orthostatic hypotension:* Symptomatic or asymptomatic decrease in blood pressure usually exceeding 20 mmHg systolic or 10 mmHg diastolic on moving from the supine to an upright position.<sup>13</sup>

*Dependent oedema:* A clinically detectable increase in extracellular fluid volume localized in a dependent area, such as a limb, characterized by swelling or pitting.

*Hypertension:* (arterial blood pressure >140/90 mmHg).<sup>12</sup>

*Autonomic dysreflexia:* A constellation of signs and/or symptoms in SCI above T5-6 in response to noxious or non-noxious stimuli below the level of injury defined by an increase in systolic blood pressure (> 20mm Hg above baseline), and which may include one of the following symptoms: headache, flushing and sweating above the level of the lesion, vasoconstriction below the level of the lesion, and dysrhythmia.<sup>1,2,18-20</sup> This syndrome may or may not be symptomatic and may occur at any time following SCI.<sup>21,22</sup>

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VARIABLE NAME: Medication affecting cardiovascular function on the day of examination:

DESCRIPTION: This variable documents the medications affecting cardiovascular functions that are currently taken by the individual.

CODES: No  
Yes, anticholinergics  
Yes, antihypertensives  
Yes, antihypotensives  
Yes, cardiac (beta-blocker, antiarrhythmics, ACE etc)  
Yes, anticoagulants  
Yes, other, specify \_\_\_\_\_  
Unknown

COMMENTS: All medications affecting cardiovascular functions (heart rate, blood pressure), which are presently taken by the individual should be documented.

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VARIABLE NAME: Time performed

DESCRIPTION: This variable documents the time of collection of objective cardiovascular data.

CODES: HHMM (hours and minutes)

Unknown

COMMENTS: Cardiovascular parameters are affected by the circadian rhythms. Therefore, the exact time of evaluation should be reported in order to appreciate this variability.<sup>23,24</sup>

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VARIABLE NAME: Position during testing

DESCRIPTION: This variable documents the position of individuals during the objective evaluation.

CODES: Sitting  
Supine  
Unknown

COMMENTS: Cardiovascular parameters are affected by the position of the individual during the testing. For example blood pressure could decrease due to sitting or standing position.<sup>25-28</sup>

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VARIABLE NAME: Devices in use during the testing

DESCRIPTION: This variable documents any device(s) worn by the individual during the time of evaluation.

CODES: Abdominal binder  
Pressure stockings  
None  
Unknown

COMMENTS: The wearing of compression devices (abdominal binder or pressure stockings) could affect cardiovascular parameters during the examination.<sup>29</sup> Therefore, their use during the examination should be documented.

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VARIABLE NAME: Pulse

DESCRIPTION: This variable documents the heart rate of individuals during the evaluation.

CODES: \_\_\_\_\_beats per minute (bpm)  
Regular  
Irregular

COMMENTS: Heart rate is a standard cardiovascular parameter documented during evaluations. The time post injury, as well as level and

completeness of spinal cord lesion are crucial factors that affect the heart rate. Individuals with injuries at T6 and below have preserved sympathetic and parasympathetic control to the heart and do not exhibit heart rate abnormalities related to spinal cord lesion.<sup>30</sup> Both abnormal heart rate and rhythm are commonly observed in individuals with cervical and high thoracic spinal cord lesions.<sup>10,31,32</sup>

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VARIABLE NAME: Blood pressure

DESCRIPTION: This variable documents the systolic and diastolic blood pressure during evaluation.

CODES: \_\_\_/\_\_\_ mmHg

COMMENTS: Low resting arterial blood pressure is common in individuals with spinal cord lesions at T6 and above.<sup>33,34</sup> Furthermore, these individuals are also prone to abnormal fluctuation of arterial blood pressure due to orthostatic instability or episodes of autonomic dysreflexia. Individuals with lesions at the lower thoracic spinal cord or below usually demonstrate normal arterial blood pressure due to preserved sympathetic control to the heart and splanchnic circulation.<sup>1,2,35</sup>

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## Reference List

1. Krassioukov,A. & Claydon,V.E. The clinical problems in cardiovascular control following spinal cord injury: an overview. *Prog. Brain Res.* **152**, 223-229 (2006).
2. Mathias,C.J. & Frankel,H.L. Autonomic Failure, A Textbook of Clinical Disorders of the Autonomic Nervous System. Bannister,R. & Mathias,C.J. (eds.), pp. 839-881 (Oxford Medical Publications,2002).
3. DeVivo,M.J., Krause,J.S. & Lammertse,D.P. Recent trends in mortality and causes of death among persons with spinal cord injury. *Arch. Phys. Med. Rehabil* **80**, 1411-1419 (1999).
4. Garshick,E. *et al.* A prospective assessment of mortality in chronic spinal cord injury. *Spinal Cord* **43**, 408-416 (2005).
5. Bauman,W.A. & Spungen,A.M. Coronary heart disease in individuals with spinal cord injury: assessment of risk factors. *Spinal Cord* (2008).
6. Krassioukov,A.V. *et al.* Assessment of autonomic dysfunction following spinal cord injury: rationale for additions to the International Standards for Neurological Assessment. *J. Rehabil. Res. Dev.* **44**, 103-112 (2007).
7. Biering-Sorensen,F. *et al.* International Spinal Cord Injury Data Sets. *Spinal Cord* **44**, 530-534 (2006).
8. DeVivo,M. *et al.* International Spinal Cord Injury Core Data Set. *Spinal Cord* **44**, 535-540 (2006).
9. Gilgoff,I.S., Ward,S.L. & Hohn,A.R. Cardiac pacemaker in high spinal cord injury. *Arch. Phys. Med. Rehabil.* **72**, 601-603 (1991).
10. Franga,D.L., Hawkins,M.L., Medeiros,R.S. & Adewumi,D. Recurrent asystole resulting from high cervical spinal cord injuries. *Am. Surg.* **72**, 525-529 (2006).
11. Kalahasty,G. & Ellenbogen,K. The role of pacemakers in the management of patients with atrial fibrillation. *Med Clin. North Am.* **92**, 161-xii (2008).
12. Pickering,T.G. *et al.* Recommendations for blood pressure measurement in humans and experimental animals: part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. *Circula.* **111**, 697-716 (2005).
13. Consensus statement on the definition of orthostatic hypotension, pure autonomic failure, and multiple system atrophy. The Consensus Committee of the American Autonomic Society and the American Academy of Neurology. *Neurol.* **46**, 1470 (1996).

14. Prevention of thromboembolism in spinal cord injury. Consortium for Spinal Cord Medicine. *J Spinal Cord Med* **20**, 259-283 (1997).
15. Kodounis,A., Stamboulis,E., Constantinidis,T.S. & Liolios,A. Measurement of autonomic dysregulation in multiple sclerosis. *Acta Neurol. Scand.* **112**, 403-408 (2005).
16. Merkelbach,S. *et al.* Multiple sclerosis and the autonomic nervous system. *J Neurol.* **253 Suppl 1**, I21-I25 (2006).
17. Mathias,C.J. Parkinson's disease. Battistin,L., Scarlato,G., Caraceni,T. & Ruggieri,S. (eds.), pp. 383-391 (Lippincott-Raven, Philadelphia,1996).
18. Krassioukov,A.V., Furlan,J.C. & Fehlings,M.G. Autonomic dysreflexia in acute spinal cord injury: an under-recognized clinical entity. *J. Neurotrauma* **20**, 707-716 (2003).
19. Gao,S.A., Ambring,A., Lambert,G. & Karlsson,A.K. Autonomic control of the heart and renal vascular bed during autonomic dysreflexia in high spinal cord injury. *Clin. Auton. Res.* **12**, 457-464 (2002).
20. Karlsson,A.K., Friberg,P., Lonroth,P., Sullivan,L. & Elam,M. Regional sympathetic function in high spinal cord injury during mental stress and autonomic dysreflexia. *Brain* **121**, 1711-1719 (1998).
21. Kirshblum,S.C., House,J.G. & O'connor,K.C. Silent autonomic dysreflexia during a routine bowel program in persons with traumatic spinal cord injury: a preliminary study. *Arch. Phys. Med. Rehabil.* **83**, 1774-1776 (2002).
22. Linsenmeyer,T.A., Campagnolo,D.I. & Chou,I.H. Silent autonomic dysreflexia during voiding in men with spinal cord injuries. *J. Urol.* **155**, 519-522 (1996).
23. Davidson,C., Smith,D. & Morgan,D.B. Diurnal pattern of water and electrolyte excretion and body weight in idiopathic orthostatic hypotension. The effect of three treatments. *Am. J. Med.* **61**, 709-715 (1976).
24. Munakata,M., Kameyama,J., Nonukawa,T., Moriai,N. & Yoshinaga,K. Circadian blood pressure rhythm in patients with higher and lower spinal cord injury: simultaneous evaluation of autonomic nervous activity and physical activity. *J. Hypertens.* **15(12)**, 1745-1749 (1997).
25. Sidorov,E.V. *et al.* Orthostatic hypotension in the first month following acute spinal cord injury. *Spinal Cord* (2007).
26. Claydon,V.E. & Krassioukov,A. Orthostatatic hypotention and autonomic pathways following spinal cord injury. *J Neurotrauma* **23**, 1713-1725 (2006).
27. Mathias,C.J. Orthostatic hypotension and paroxysmal hypertension in humans with high spinal cord injury. *Prog. Brain Res.* **152**, 231-243 (2006).

28. Krassioukov,A.V., Warburton,D.E., Teasell,R. & Eng,J.J. Spinal Cord Injury Rehabilitation Evidence (SCIRE). Eng,J.J. & Teasell,R. (eds.), pp. 16-1-16-15 (ICORD, Vancouver,2007).
29. Hopman,M.T., Monroe,M., Dueck,C., Phillips,W.T. & Skinner,J.S. Blood redistribution and circulatory responses to submaximal arm exercise in persons with spinal cord injury. *Scand. J. Rehabil. Med.* **30**, 167-174 (1998).
30. Lehmann,K.G., Shandling,A.H., Yusi,A.U. & Froelicher,V.F. Altered ventricular repolarization in central sympathetic dysfunction associated with spinal cord injury. *Am. J. Cardiol.* **63**, 1498-1504 (1989).
31. Claydon,V.E., Elliott,S.L., Sheel,A.W. & Krassioukov,A. Cardiovascular responses to vibrostimulation for sperm retrieval in men with spinal cord injury. *J. Spinal Cord Med.* **29**, 207-216 (2006).
32. Silbert,P.L. & Davis,M.J.E. Late Asystole in High Cervical Spinal-Cord Injury - Case-Report. *Parap.* **28**, 137-140 (1990).
33. Mathias,C.J. & Frankel,H.L. Handbook of Clinical Neurology. Frankel,H.L. (ed.), pp. 435-456 (Elsevier Science Publishers, B.V.,1992).
34. Sheel,A.W., Krassioukov,A.V., Inglis,J.T. & Elliott,S.L. Autonomic dysreflexia during sperm retrieval in spinal cord injury: influence of lesion level and sildenafil citrate. *J. A. Physiol.* **99**, 53-58 (2005).
35. Teasell,R., Arnold,A.P., Krassioukov,A.V. & Delaney,G.A. Cardiovascular consequences of loss of supraspinal control of the sympathetic nervous system following spinal cord injuries. *Arch Phys Med Rehabil* **81**, 506-516 (2000).

**INTERNATIONAL SPINAL CORD INJURY DATA SETS**  
**CARDIOVASCULAR BASIC DATA SET – DATA FORM**

**Date performed:** YYYYMMDD     Unknown

**Cardiovascular history before spinal cord lesion (collected once):**

- Cardiac pacemaker, date last inserted YYYYMMDD
- Cardiac surgery, specify \_\_\_\_\_, date last performed YYYYMMDD
- Other cardiac disorders, specify \_\_\_\_\_
- Hypertension
- Hypotension
- Orthostatic hypotension
- Deep vein thrombosis
- Neuropathy (alcoholic, diabetic, and others)
- Other, specify \_\_\_\_\_
- Unknown

**Events related to cardiovascular function after spinal cord lesion:**

- Cardiac pacemaker, date YYYYMMDD
- Myocardial infarction, date YYYYMMDD
- Stroke, date YYYYMMDD
- Deep vein thrombosis, date YYYYMMDD
- Other, specify \_\_\_\_\_, date YYYYMMDD
- Unknown

**Cardiovascular function after spinal cord lesion within the last three months:**

- Cardiac conditions, specify \_\_\_\_\_
- Orthostatic hypotension
- Dependent oedema
- Hypertension
- Autonomic dysreflexia
- Deep vein thrombosis, date YYYYMMDD
- Other, specify \_\_\_\_\_
- Unknown

**Any medication affecting cardiovascular function on the day of examination:**

- No             Yes, anticholinergics
- Yes, antihypertensives
- Yes, antihypotensives
- Yes, cardiac
- Yes, other, specify \_\_\_\_\_
- Unknown

**Objective measures:**

**Time performed:** HHMM             Unknown

**Position during testing:**             Sitting     Supine     Unknown

**Devices in use during testing:**     Abdominal binder     Pressure stockings  
    None                             Unknown

**Pulse:** \_\_\_\_\_ beats per minute (bpm)  
    Regular                             Irregular

**Blood pressure:** \_\_\_\_/\_\_\_\_ mmHg