Clinical Assessment Following Acute Cervical Spinal Cord Injury

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RECOMMENDATIONS

Neurological Examination:

Level II:

- The American Spinal Injury Association international standards for neurological and functional classification of spinal cord injury are recommended as the preferred neurological examination tool for clinicians involved in the assessment and care of acute spinal cord injury patients.

Functional Outcome Assessment:

Level I:

- The Spinal Cord Independence Measure III is recommended as the preferred functional outcome assessment tool for clinicians involved in the assessment, care, and follow-up of patients with spinal cord injuries.

Pain Associated With Spinal Cord Injury:

Level I:

- The International Spinal Cord Injury Basic Pain Data Set is recommended as the preferred means to assess pain, including pain severity, physical functioning, and emotional functioning, among SCI patients.

RATIONALE

Acute traumatic spinal cord injury (SCI) affects 12 000 to 15 000 people in North America each year. The functional consequences of an acute SCI are variable; therefore, the initial clinical presentation of patients with an acute SCI is a key factor in determining triage, defining therapy, and predicting prognosis. The patient must be assessed with an accurate, consistent, and reproducible neurological assessment scale to define the acute SCI patient's neurological deficits and to facilitate communication about patient status to caregivers. The early neurological status of an injury victim as described by an ideal neurological assessment scale should also have prognostic value for that patient's neurological future. The comprehensive clinical assessment of the SCI patient should both accurately describe the patient's neurological function (motor and sensory examinations) and generally predict that patient's future relative abilities and/or impairment given the patient's neurological status. Prognostic information provided by comparing current injury victims and the functional outcomes of historical patients with similar injuries is of value to patients and families. The evaluation of new therapies proposed for the treatment of acute SCI requires the use of accurate, reproducible neurological assessment scales and reliable functional outcome measurement tools to measure potential neurological improvement after therapy and, importantly, to determine its functional significance.

ABBREVIATIONS: ASIA, American Spinal Injury Association; **FIM,** Functional Independence Measure; **ISCIBPDS,** Spinal Cord Injury Basic Pain Data Set; **QIF,** Quadriplegic Index of Function; **SCI,** spinal cord injury; **SCIM,** Spinal Cord Independence Measure

Pain of the spinal cord, spinal column, or other orthopedic origin is often of clinical significance following acute SCI. Pain can be horribly debilitating, hindering patient performance and limiting functional abilities beyond that predicted by the patient's neurological deficits. These 3 topics (neurological assessment, functional outcome, and pain associated with SCI) are the focus of this contemporary update on the Clinical Assessment Following Acute Spinal Cord Injury, previously produced and published by the Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons.[1]

SEARCH CRITERIA

A computerized search of the database of the National Library of Medicine (PubMed) of the literature published from 1966 to 2011 was performed for each of the 3 subtopics reviewed in this guideline: neurological assessment, function outcome, and pain following SCI. The search was limited to the English language, the human literature, and reviews, case series, meta-analyses, and randomized clinical trials of adult patients published between 1966 and 2011. The term "spinal cord injury" was combined with the term "neurological assessment," yielding 1444 references. A second search using the terms "spinal cord injury" and "assessment scales" yielded 81 references. A third search employing the terms "spinal cord injury" and "assessment scores" revealed 178 publications. A search using "ASIA impairment scale" yielded 351 citations. A search using the terms "ASIA classification" and "spinal cord" yielded 113 references (total, 2167).

For functional outcome, each PubMed database search was limited to the English language, the human literature, and reviews, case series, meta-analyses, and randomized clinical trials published between 2000 and 2010. Search terms "spinal cord injury" and "functional outcomes assessment" yielded 448 references. Search terms "spinal cord injury" and "functional outcome scales" yielded 28 citations. A search for "functional independence measure" resulted in 1132 references. A search for "spinal cord independence measure" revealed 190 citations (total, 1798).

For pain following SCI, each PubMed database search was limited to the English language, the human literature, and reviews, case series, meta-analyses, and randomized clinical trials published between 1966 and 2010. Search terms "spinal cord injury" and "pain" resulted in 2093 references. Search terms "spinal cord injury" and "pain classification" yielded 91 citations. A search using the terms "spinal cord injury" and "pain assessment scales" produced 26 references. Search terms "spinal cord injury" and "pain assessment scale" resulted in 121 references (total 2331).

The 733 references for neurological assessment, the 520 references for functional outcome, and the 1050 citations for pain following SCI were imported into a database, and duplicates were eliminated. Articles germane to each of the 3 topics were selected by reviewing their titles and abstracts. Additional references were culled from the reference lists of the remaining papers. Finally, members of the author group were asked to contribute articles known to them on the subject matter that were not found by other search means. The citations critical to the formulation of this guideline on each of the 3 topics are provided in Evidentiary Table format (Tables 1-3).

SCIENTIFIC FOUNDATION

A variety of neurological assessment systems/scales have been utilized for the documentation of the neurological status of patients following SCI. They include the Frankel Scale; the modified Frankel Scale; the Lucas and Ducker Neurotrauma Motor Index; the Sunnybrook, the Botsford, and the Yale scales; the NASCIS scale; the American Spinal Injury Association (ASIA) scale; and the ASIA/International Medical Society of Paraplegia international standards for neurological and functional classification of SCI scale, now referred to as the American Spinal Injury Association Classification Standards.[2-21]

Several of these assessment scales have been refined through serial iterations.[2,4,8-11,17,19,20,22] A few are widely used, while others have not attained general acceptance and recognition. Ideally, the clinical neurological assessment of acute SCI victims should be uniform, reproducible, and thorough yet easy to use. The assessment tool must be detailed and precise to specifically document a given patient's injury and must provide descriptive measurement scales that allow determination of loss or gain of function with time and therapy. Nearly simultaneously, there must be correlation of the patient's functional abilities relative to their neurological examination to document whether losses or gains have meaningful significance to the patient and to accurately determine outcome. This is typically accomplished using a scale to quantify Functional Outcome in conjunction with a Neurological Assessment scale. Whatever assessment system(s) is/are used, it/they must be consistent and accurate and have interrater reliability. Difficulties exist when clinicians utilize poorly defined measurement tools or different methods of neurological assessment to describe the same patient, hindering the definition (potentially the management) of that patient by different clinicians and the comparison of that patient with other patients with similar injuries. The accurate assessment of both the neurological status and the functional skills of acute SCI patients is essential for patient management, the conduct of research studies, and comparisons of clinical therapeutic trials.

Numerous assessment scales have been used to evaluate patients with SCI. Scales may be divided into 2 general types. The first type is examination-specific and focuses on the neurological deficits suffered as a result of SCI. These scales use the motor and sensory examination primarily (or exclusively) to assign a numerical value or letter grade.[4,8,9,12,15,17-20,23] The second type of scale focuses on functional skills, including a patient's ability to care for himself or herself, participate in personal hygiene, transfer, or ambulate.[10,11,22,24-34] In general, the first type of scale is used for the acute assessment of patients with SCI, whereas both assessment scales are used to define the chronically injured patient. The contemporary assessment of SCI patients incorporates both neurological examination scales and functional outcome/assessment scales to most accurately describe individual patients.[10,11,35] Finally, the clinical assessment of patients with acute SCI should include an assessment of pain severity, physical functioning, and emotional functioning experienced by that patient. Several pain classification systems have been developed, and 13 pain intensity instruments have been designed and utilized to describe pain among SCI patients.[36-38]

NEUROLOGICAL EXAMINATION SCALES

A comprehensive medical evidence-based review of neurological assessment scales used to assess acute adult SCI patients was published in 2002.[1] In 2002, based on the best medical evidence in the literature to that point, the guidelines author group concluded that the 1996 ASIA standards was the most valid and reliable neurological assessment scale available to clinicians who care for these patients. This recommendation was offered as an Option Level or Level III recommendation.

Since the 2002 guideline publication, several investigators have further studied the reliability and validity of the ASIA standards as a neurological examination scale for adult patients following acute SCI. Kirshblum et al compared the revised 2000 ASIA Classification Standards with the previous 1996 ASIA standards. Ninety-four subjects with SCI who were assessed with the 1996 standards at 1 week and 1 year after injury were retrospectively reassessed using the revised 2002 ASIA Standards. They found nearly perfect agreement between the 2 scales (weighted κ scores between 0.995 and 0.91; confidence intervals between 0.79 and 1.0). Three of 17 ASIA C categorized patients based on the 1996 standards were categorized as ASIA B using the 2000 standards, a distinction that had no impact on prognosis at 1 year follow-up examination.

In 2003, Burns and colleagues[39] retrospectively discovered that 5 of 81 acute SCI patients (6%) initially scored as ASIA A injuries at their institution were reclassified as ASIA B within the first week of injury. They used 1-year follow-up assessments for comparison. They cited closed head injury, drug effects, mechanical ventilation, and psychological disorders as factors that could potentially interfere with the ability to accurately examine a patient. They concluded that these factors could diminish the reliability of the initial examination on admission.

Marino and Graves[3] reported on the metrics of the ASIA motor score in correlation with functional activities and functional impairment in 2004.They used item response theory methods to determine the value of the use of ASIA motor score/subscores to predict motor Functional Independence Measure (FIM) instrument scores among a database of 4338 SCI patients discharged from inpatient rehabilitation between 1994 and 2003. They concluded that functional impairment following SCI is more accurately described by the use of separate upper- and lower-extremity ASIA motor scores rather than a single, total ASIA motor score. Similarly, in 2006, Graves et al[21] concluded that the use of upper- and lower-extremity motor scales will reduce measurement error when the ASIA motor score is used as a predictor of outcome. In an assessment of the ASIA motor score scales in 6116 SCI patients, they found that the use of 2 scales was more accurate and could distinguish between complete paraplegia and incomplete SCI (in both instances the ASIA motor score could equal 50) more reliably than the use of a single total ASIA motor scale score.

In 2007, Slavic et al[2] reported on the interrater reliability of the ASIA standards motor and sensory examinations performed by 2 experienced examiners in a prospective observational study and assessment of 45 SCI patients. The total ASIA score showed a very strong correlation between the 2 examiners with Pearson correlation coefficients and intraclass correlation coefficients exceeding 0.99 for total motor and light touch scores and 0.97 for pinprick scores. Weighted κ values for myotome determination when a sufficient number of observations allowed statistical analysis were 0.785 to 0.981, indicating substantial to almost perfect agreement. Level of agreement between the 2 examiners for level of injury ranged between 73% and 80%. The unweighted κ coefficient for agreement in motor and sensory levels ranged from 0.68 to 0.78, indicating substantial agreement (Class II medical evidence). There was no difference in ASIA impairment grades between the 2 examiners' results.

Furlan et al[40,41] performed 2 similar but separate literature reviews and have produced 2 publications on the psychometric properties of the ASIA Standards, one in 2008 and the other in 2010. There is no accepted "gold standard" neurological assessment examination against which to compare all others. They reported that the ASIA standards have not been evaluated adequately with respect to several of the 8 quality criteria for psychometric properties of instruments as proposed by Terwee and colleagues.[42] Convergent construct validity, reliability, and responsiveness have been the criteria of the ASIA standards most rigorously scientifically studied. There are recognized minor variances noted among investigators in each criterion as summarized above. There is the potential for floor effects on the motor score assessment among paraplegic patients (no measure of motor function between T1 and L1) and a ceiling effect among the quadriplegic patients (injury above measurable motor units), which can affect scoring scale accuracy and hinder comparison to other similarly injured SCI patients. The ASIA standards cannot be accurately applied to SCI patients who cannot be accurately examined owing to confounding factors[39] (This is not a failure/weakness of the scoring scale) and are not applicable to adolescents and children.[43,44] Despite these few, but real, potential problematic features, the 2000 American Spinal Injury Association (ASIA) Standards is the most consistent, reliable, valid and responsive scoring system for the Neurological Assessment of adult patients with acute SCI, to a high degree of scientific certainty.[2,4,40,41]

FUNCTIONAL OUTCOME SCALES

Functional outcome scales are measures of human performance and ability/disability typically defined during medical rehabilitation, ie, how a person functions with activities of everyday life after injury/impairment/debilitating illness. Several scales have been employed or developed in an effort to accurately characterize an injury victim's functional skills and disabilities after SCI in order to quantify his or her functional independence.[10,11,22,24,25,27-31,34,45-53] They attempt to determine a patient's ability or inability to function and/or live independently. Scales for functional rating include the Barthel Index, the modified Barthel Index, the FIM, the Quadriplegic Index of Function (QIF), the Spinal Cord Independence Measure (SCIM), the Walking Index for SCI, the Spinal

TABLE 1. Evidentiary Table: Clinical Neurological Assessment: Neurological Examination[a]

Reference	Description of Study	Evidence Class	Conclusions
Savic et al,[2] *Spinal Cord*, 2007	Assessment of interrater reliability of motor/sensory examinations of ASIA standards	II	κ Values for agreement in motor and sensory examinations, 0.68-0.78, indicating substantial agreement.
Graves et al,[21] *Journal of Spinal Cord Medicine*, 2006	Comparison of total ASIA motor score with separate upper- and lower-extremity scales to describe SCI	III	Use of upper- and lower-extremity scores will reduce measurement error compared to total ASIA motor score.
Marino and Graves,[3] *Archives of Physical Medicine and Rehabilitation*, 2004	IRT methods to assess total ASIA motor score vs ASIA subscores for upper/lower extremity to predict FIM	III	Impairment from SCI is more accurately characterized using upper-/lower-extremity ASIA subscores.
Burns et al,[39] *Journal of Neurotrauma*, 2003	Assessment of early ASIA grade with one week and one year follow-up.	III	Earliest ASIA grade assignment may be inaccurate due to confounding features that limit examination.
Kirshblum et al,[4] *American Journal of Physical Medicine and Rehabilitation*, 2002	Comparison of 2000 ASIA standards to 1996 ASIA standards	I	There was near-perfect agreement between 1996 and 2000 ASIA standards.
Jonsson et al,[108] *Spinal Cord*, 2008	To determine the interrater reliability of the ISCSCI-92	III	This study indicates a weak interrater reliability for scoring incomplete SCI lesions using the ISCSCI-92.
Cohen et al,[109] *Spinal Cord*, 1998	A test of the ISCSCI-92	III	Further revisions of the 1992 ASIA standards and more training are needed to ensure accurate classification of SCI.
El Masry et al,[26] *Spine*, 1996	Validation of the ASIA motor score and the NASCIS motor score	III	The ASIA and NASCIS motor scores can both be used for the neurological quantification of motor deficit and motor recovery.
Wells and Nicosia,[35] *Journal of Spinal Cord Medicine*, 1995	Comparison of Frankel Scale, Yale Scale, Motor Index Score, modified Barthel Index, and Functional Independence Measure	III	The best assessment tool is a combination of 2 scales, one based on impairment and the other on disability.
Waters et al,[110] *Archives of Physical Medicine and Rehabilitation*, 1994	ASIA compared with motor scores based on biomechanical aspects of walking	III	ASIA motor score strongly correlates with walking ability.
Davis et al,[111] *Spine*, 1993	Reliability of Frankel and Sunnybrook scales	III	Demonstrated high inter-rater reliability of Frankel and Sunnybrook scales.
Bednarczyk and Sanderson,[112] *Journal of Rehabilitation Research and Development*, 1993	Compared several classification systems within the same group of spinal cord–injured subjects	III	ASIA scale showed the greatest discrimination in grouping subjects with SCI.
Botsford and Esses,[13] *Orthopedics*, 1992	Description of a new functionally oriented scale with assessment of motor and sensory function, rectal tone, and bladder	III	Scale was more sensitive for the detection of improvement in function.
Priebe and Waring,[113] *A American Journal of Physical Medicine and Rehabilitation*, 1991	Interobserver reliability of the 1989 revised ASIA standards for neurological classification of spinal injury patients	III	The interobserver reliability for the revised ASIA standards is improved but continues to be less than optimal. They recommended changes.
Bracken et al,[114] 1990, *New England Journal of Medicine*	Multicenter North American trial examining effects of methylprednisolone or naloxone in ASCI (NASCIS II)	III for neuro assessment	Motor scores of 14 muscles on 5-point scale, right side of body only. Sensory scores of pinprick and light touch, 3-point scale, bilateral. No interrater reliability comparison.
Lazar et al,[115] *Archives of Physical Medicine and Rehabilitation*, 1989	Relationship between MIS and the modified Barthel Index	III	The MIS is useful in predicting function during rehabilitation, although individual differences in ambulation limit its predictive utility.
Bracken et al,[6] 1984, *JAMA*	Methylprednisolone in SCI	III for neuro assessment	Description of NASCIS motor score.

(Continues)

TABLE 1. *Continued*

Reference	Description of Study	Evidence Class	Conclusions
Tator et al,[20] *Early Management of Acute Spinal Cord Injury*, 1982	Description of a 10-grade numerical neurological assessment scale	III	Improvement from the Frankel scale. Motor grading is not very sensitive.
Chehrazi et al,[15] *Journal of Neurosurgery*	Description of Yale scale	III	Provides assessment of the severity of SCI and the prognosis for recovery.
Lucas and Ducker,[18] *American Surgeon*, 1979	A motor classification of patients with SCI injuries with statistically discrete subdivisions; the patients in each of the subdivisions of the classification can be mathematically summarized with numerical indices, which can be accurately analyzed statistically	III	Allows the clinical researcher to evaluate current treatments and assess the potential of new treatments and to assess the potential of new treatment regimens.
Bracken et al,[7] *Paraplegia*, 1978	Description of 133 ASCI patients classified using motor and sensory scales developed by Yale SCI Study Group	III	Considerable discrepancy between motor and sensory impairment scales among patients with greater motor than sensory loss.
Frankel et al,[17] *Paraplegia*, 1969	5-Category scale used in a large study to assess neurologic recovery in patients treated with postural reduction of spinal fractures	III	Present results in terms of defined degrees of neurological involvement.

[a]ASCI, acute spinal cord injury; ASIA, American Spinal Injury Association; FIM, Functional Independence Measure; IRT, item response theory; ISCSCI-92, International Standards Classification of Spinal Cord Injury 1992; MIS, Motor Index Score; NASCIS, National Acute Spinal Cord Injury Study; SCI, spinal cord injury.

Cord Injury Functional Ambulation Inventory, and the recently proposed SCI Computer Adaptive Test.[10,11,22,24,25,27-34,45,47-57] They are applicable to a wide range of nervous system disorders; however, the QIF, the Spinal Cord Injury Functional Ambulation Inventory, and the SCIM were developed specifically for patients with SCI and are reportedly more specific and sensitive for patients with SCI.[24,27,32,48,53,58,59] All of these scales have been successfully used to characterize the functional abilities of SCI patients.[10,11,22,24,25,27-31,45,47-52,54] A comprehensive medical evidence-based review of functional outcome scales was published in 2002.[1] On the basis of the best medical evidence published in the English language literature through 2001 on adult SCI patients, the guidelines author group advocated the use of the FIM as the functional outcome assessment tool of choice for SCI patients at a Guideline Level (Level II) recommendation.[1]

As described in the original guideline on the topic, FIM has proven to be a reliable, valid tool to assess the functional abilities of compromised patients with respect to activities of daily living and to assess the burden of care of those patients for a variety of medical disorders.[32,60] Several investigator groups have been critical of FIM and its applicability to patients with neurological dysfunction following SCI.[32,61] While widely used, FIM was not developed specifically for patients with SCI. It has been cited for its lack of sensitivity, particularly in locomotion, mobility, respiration, and bladder/bowel sphincter function items among patients with SCI.[61] To address the shortcomings of FIM in documenting patient disability and the degree of functional recovery among SCI patients, 3 SCI-specific functional assessment scales were developed. The QIF, developed in 1980 to describe the functional skills and abilities of tetraplegic patients (complete high cervical SCI patients), has poor applicability to the whole of the adult SCI population.[27,32,62] The same is true of the Spinal Cord Injury Functional Ambulation Inventory, proposed in 2001, and the Walking Index for SCI. Both are tools to assess the walking abilities of patients with incomplete SCI.[34,48,56,63]

SCIM was proposed in 1997 as a new disability scale specific for patients with spinal cord pathology.[24] An international collaborative author-investigator group has twice revised SCIM.[33,64] In its current iteration, the SCIM III has been studied in detail and is reported to be sensitive, specific, valid, and reliable for the assessment of disability among SCI patients, both early and late after SCI.[32,58,64,65] The SCIM instrument focuses on the patient's ability to perform everyday tasks and captures the economic burden of disability, as well as the impact of their disability on the patient's overall medical condition and comfort. It consists of 3 subscales that cover the related but distinct subsets of self-care (6 items; score range, 0-20), respiration and sphincter management (4 items; score range, 0-40), and mobility (9 items; score range, 0-40). The total score ranges from 0 to 100. The mobility subset is further subdivided into 2 subscales: room and toilet, and indoors and outdoors. Individual item scores range from 2 to 9 points. SCIM scores a task higher in patients who accomplish it with less assistance, aids, or medical compromise than other patients.

SCIM was introduced by Catz et al[24] in 1997. This author group described the assessment of 30 patients with spinal cord pathology using SCIM. They assessed the interrater reliability

TABLE 2. Evidentiary Table: Clinical Neurological Assessment: Functional Outcome Assessment[a]

Reference	Description of Study	Evidence Class	Conclusions
Ackerman et al,[53] *Spinal Cord*, 2010	Assessment of SCIM III as functional outcome tool after acute rehabilitation	III	SCIM III is sensitive, effective for outcome after rehabilitation. Floor/ceiling effects identified in some subgroups.
Bluvshtein et al,[58] *Spinal Cord*, 2010	Analysis of reliability and validity of SCIM III	I	κ Values of 0.649-0.858 for all SCIM III tasks. SCIM III more responsive than FIM.
Glass et al,[60] *Journal of Rehabilitation Medicine*, 2009	Analysis of SCIM III and FIM in SCI patients in the United Kingdom	III	SCIM III valid and reliable. Both SCIM III and FIM valid, SCIM III more sensitive than FIM.
Rudhe and van Hedel,[68] *Neurorehabilitation and Neural Repair*, 2009	Comparison of 261 patients upper-extremity SCIM III scores with arm and hand muscle strength and hand function in tetraplegic patients	II	SCIM III accurately reflects upper-extremity function in tetraplegia.
Wirth et al,[59] *Neurorehabilitation and Neural Repair*, 2008	Analysis of sensitivity of SCIM III vs ASIA scores as late functional outcome tool	III	SCIM II sensitive tool for outcome at one-year follow-up. Floor/ceiling effects noted in some subgroups.
Catz et al,[65] *Spinal Cord*, 2007	Rasch analysis of SCIM III	I	SCIM III and SCIM III subscales reliable/valid.
Itzkovich et al,[64] *Disability and Rehabilitation*, 2007	Assessment of reliability and validity of SCIM III, 2 raters	I	κ Values of 0.631-0.823 for all SCIM III tasks. SCIM III much more sensitive than FIM.
Itzkovich et al,[67] *American Journal of Physical Medicine and Rehabilitation*, 2003	Comparison of reliability of SCIM II by interview and comparison with observation	III	Reliability of SCIM II by interview good but not as good as observation.
Itzkovich et al,[66] *Spinal Cord*, 2002	Rasch analysis of SCIM II	III	Confirms validity and reliability of SCIM II.
Catz et al,[33] *Disability and Rehabilitation*, 2001	Introduction of revised SCIM (SCIM II) with comparison to SCIM and FIM	III	SCIM II supersedes SCIM.
Catz et al,[61] *Spinal Cord*, 2001	Comparison of SCIM to FIM	III	SCIM more sensitive than FIM for spinal cord lesions. Needs further refinement.
Field-Fote,[48] *Journal of Rehabilitation Medicine*, 2001	Spinal Cord Injury Functional Ambulation Inventory as functional assessment scale for gait assessment.	III	Reliable and relatively sensitive measure of walking ability in patients with ASCI. Interrater reliability good, no κ values offered.
Küçükdevec et al,[29] *Scandinavian Journal of Rehabilitation Medicine*, 2000	To determine the reliability and validity of the modified Barthel Index in Turkey	III	Adaptation of the modified Barthel Index has been successful and can be used in Turkey as long as its limitations are recognized.
Ditunno et al,[45] *Spinal Cord*, 2000	Walking Index for SCI offered as index for ambulation skills after SCI in pilot study	III	Good reliability and excellent interrater reliability but needs assessment in clinical setting.
Yavuz et al,[62] *Spinal Cord*, 1998	Assessment of the relationship of the 2 functional tests, the FIM and the QIF, to ASIA scores	III	Good, strong correlations between the FIM and the QIF to ASIA scores.
Catz et al,[24] *Spinal Cord*, 1997	SCIM as new disability scale for spinal cord lesions; 30 patients assessed with SCIM and FIM	III	SCIM more sensitive than FIM.
Hamilton et al,[116] *Scandinavian Journal of Rehabilitation Medicine*, 1994	FIM interrater reliability in the clinical setting	III	FIM is reliable when used by trained/tested inpatient medical rehabilitation clinicians.
Dodds et al,[47] *Archives of Physical Medicine and Rehabilitation*, 1993	Assessment of reliability of FIM in characterizing 11 102 UDS rehabilitation patients	III	FIM has high internal consistency and adequate discriminative capabilities and was a good indicator of burden of care.
Hamilton et al,[117] *Archives of Physical Medicine and Rehabilitation*, 1991	Interrater agreement assessment of FIM in 263 patients in 21 UDS hospitals	III	κ Values for 7-level FIM ranged from 0.61-0.76; mean, 0.71.

(Continues)

TABLE 2. *Continued*

Reference	Description of Study	Evidence Class	Conclusions
Shah et al,[31] *Journal of Clinical Epidemiology*, 1989	Description of modified Barthel Index	III	The modified Barthel Index has greater sensitivity and improved reliability than the original version, without additional difficulty or affecting the implementation time.
Gresham et al,[27] *Paraplegia*, 1986	Test of the QIF	III	The QIF was more sensitive than the Barthel Index.

[a]ASIA, American Spinal Injury Association; FIM, Functional Independence Measure; QIF, Quadriplegic Index of Function; UDS, Uniform Data System; SCI, spinal cord injury; SCIM, Spinal Cord Independence Measure.

and sensitivity of SCIM and compared their SCIM results with FIM assessments for each patient. The authors found remarkable consistency between each pair of raters (2 trained raters for each of 3 subsets) for all tasks assessed, with a κ coefficient between 0.66 and 0.98. Total agreement was > 85%. The authors found the SCIM more sensitive than FIM to changes in the functional abilities of spinal cord lesion patients over time: SCIM detected all functional changes detected by FIM, but FIM missed 26% of changes detected by SCIM scoring. The authors concluded that SCIM is a useful instrument for assessing functional changes in patients with lesions of the spinal cord. The same author group described similar results in a comparison between SCIM assessment and FIM assessment scores in 22 patients with spinal cord lesions in 2001 but suggested revision of the functional subgroups of self-care and mobility.[61]

Catz and colleagues[33] reported these revisions in 2001. SCIM II included new scales for the activities of bathing, dressing, bowel care, and mobility in bed. The correlations between the paired scores for these functional categories were r = 0.90 to 0.96 (statistically significant improvement, $P < .001$). The authors recommended that SCIM II supersede SCIM as an SCI-related functional assessment tool. Itzkovich and colleagues[66] performed a Rasch analysis of the revised SCIM assessment tool (SCIM II) and reported it in 2002. They concluded that SCIM II was a valid and reliable assessment tool and had an acceptable goodness of fit to the Rasch model (in-fit mean square = 0.8-1.2; outfit mean square = 0.6-1.4). Nonetheless, their analysis identified a few item categories that should be revised or removed to further improve SCIM. Itzkovich and coauthors[67] later demonstrated that SCIM II was also remarkably reliable when applied after interview (only) of SCI patients compared with observed examinations of the same patients by skilled examiners.

Wirth and associates[59] evaluated 64 patients with complete paraplegia and 36 with complete quadriplegia with SCIM II and compared SCIM II data to ASIA motor scores at 1, 3, 6, and 12 months after injury. They reported that median ASIA motor scores remained stable in the paraplegic group at 1-year follow-up. The quadriplegic group demonstrated significant improvement in median ASIA motor scores at 1 year, from a median of 14 points initially to 19 points 12 months after injury. They noted a floor effect on motor recovery among the paraplegic patients (no measure of motor function between T1 and L1) and a ceiling effect among the quadriplegic patients (injury above measurable motor units). Paraplegic patients had significant increases in SCIM II scores over time (median improvement, 41 points). Quadriplegic patients also demonstrated significant improvements in SCIM II scores (median improvement, 11 points) but less improvement than paraplegic patients. The functional recovery rate of patients with paraplegia was significantly higher than that of quadriplegic patients in the first 3 months after injury; however, the annualized functional recovery rate was comparable between the 2 groups of patients. Floor and ceiling effects previously described with ASIA motor scores were identified with SCIM II scores as well. There was no correlation between functional and motor recovery in paraplegic patients; however, a fair correlation was observed with quadriplegic patients. These authors concluded that functional recovery is a continuous process in the first year after SCI and that SCIM II is a sensitive, responsive, valuable assessment tool complementary to the ASIA standards for monitoring rehabilitation outcome in SCI.

A new and improved SCIM scale (SCIM III) was reported by Itzkovich et al in 2007. Four hundred twenty-five patients with spinal cord lesions from 13 centers in 6 countries were evaluated with SCIM III and FIM on admission to rehabilitation and upon discharge. SCIM III was tested for interrater reliability (agreement between raters, κ coefficients, Pearson correlation, and interclass correlation coefficients) and the internal consistency of scale (Cronbach coefficient). Total agreement between raters ranged between 74.5% and 96.2%; total agreement was > 80% in 13 of the 18 tasks. The κ coefficients ranged between 0.631 and 0.823 ($P < .001$). Pearson coefficients of the 3 SCIM III subscales and total SCIM III were > 0.9 ($P < .001$). Interclass correlation values were > 0.94 for total SCIM III and all SCIM III subscales. Cronbach α values for SCIM III were 0.847 and 0.849. Pearson correlation coefficients between SCIM III and FIM were 0.790 and 0.779 for the 2 raters, respectively. The responsiveness of SCIM III was statistically significantly better than that of FIM in the respiration and sphincter management and mobility indoors

TABLE 3. Evidentiary Table: Clinical Neurological Assessment: Pain Associated With SCI[a]

Reference	Description of Study	Evidence Class	Conclusions
Jensen et al,[107] *Spinal Cord*, 2010	Assessment of Spinal Cord Injury Basic Pain Data Set in 184 SCI patients with pain	I	Excellent internal consistency (reliability) (Cronbach's α = 94). Validity statistically significant, $P < .01$.
Dijkers,[91] *Journal of Spinal Cord Medicine*, 2010	Comparison of quantification of SCI pain by Verbal Rating Scale and Numeric Rating Scale	III	Considerable variation in patient interpretation and use of Verbal Rating Scale and Numeric Rating Scale to describe pain.
Attal et al,[90] *Pain*, 2008	Characterization and quantification of neuropathic pain from nerve, spinal cord, and brain lesions with NPSI	III	NPSI revealed several positive correlations but not specific or reliable.
Hanley et al,[81] *Journal of Pain*, 2008	Assessment of pain catastrophizing and beliefs on pain after SCI	III	Pain catastrophizing associated with greater pain interference and poorer psychological functioning.
Felix et al,[74] *Journal of Rehabilitation Research and Development*, 2007	Assessment of chronic pain after SCI with descriptions, Numeric Rating Scale, IASP taxonomy	III	Sharp pain most disturbing, more frequently interferes with activities and sleep.
Budh and Osteråker,[80] *Clinical Rehabilitation*, 2007	Assessment of self-reported life satisfaction after SCI; questionnaire with Lisat-9 and Verbal Rating Scale	III	SCI pain negatively affects life satisfaction compared to SCI patients without pain.
Wollaars et al,[83] *Clinical Journal of Pain*, 2007	Comprehensive questionnaire assessment of psychological factors on SCI and impact of SCI pain on quality of life	III	Chronic SCI pain and poor quality of life associated with pain catastrophizing and SCI helplessness.
Hanley et al,[92] *Clinical Journal of Pain*, 2006	Assessment of change in pain intensity in patients with SCI or limb amputation	III	An approximate 33% decrease in pain is considered a reasonable standard for meaningful change in chronic pain.
Hanley et al,[101] *Journal of Pain*, 2006	Classification of SCI pain; mild, moderate, and severe	III	Classification of SCI pain may be useful for applying clinical treatment guidelines and for interpreting results of future clinical trials.
Bryce et al,[36] *Journal of Spinal Cord Medicine*, 2006	Assessment of Bryce/Ragnarsson SCI pain taxonomy using clinical vignettes	II	"Substantial" interrater agreement in determining subtypes of pain, κ Values between 0.55 and 0.91. Not applied to patients.
Raichle et al,[97] *Journal of Pain*, 2006	Survey assessment of reliability and validity of Graded Chronic Pain Disability Scale Disability and Brief Pain Inventory of Wisconsin Interference scales	III	Graded Chronic Pain Disability Scale Disability and Brief Pain Inventory of Wisconsin Interference scales appear reliable and valid.
Widerstrom-Noga et al,[105] *Archives of Physical Medicine and Rehabilitation, 2006*	Assessment of consistency, stability, and validity of the Multidimensional Pain Inventory	III	Multidimensional Pain Inventory appears to be a reasonable measure for evaluating chronic pain and its impact after SCI.

(Continues)

TABLE 3. *Continued*

Reference	Description of Study	Evidence Class	Conclusions
	Moderate to substantial reliability: 8 of 10 subscales		
	High construct validity in 9 of 10 subscales		
Salisbury et al,[99] *Spinal Cord*, 2006	Assessment of shoulder pain following tetraplegia using Wheelchair Users Shoulder Pain Index, McGill Pain Questionnaire, and Numeric Rating Scale	III	High incidence of shoulder pain after SCI even among those patients not confined to wheelchairs.
Cruz-Almeida et al,[71] *Journal of Rehabilitation Research and Development*, 2005	Questionnaire assessment of self-reported pain and pain interference with sleep and daily activities; confirmatory factor analysis	III	Chronic nociceptive and neuropathic pain are consistent after SCI and have negative impact on sleep and activities of daily living.
Lund et al,[93] *BMC Medical Research Methodology*, 2005	Comparison of Visual Analog Scale and Verbal Rating Scale in cross-sectional study of chronic pain (not isolated SCI pain)	III	Visual Analog Scale and Verbal Rating Scale not interchangeable. Visual Analog Scale may overestimate or underestimate perceived pain.
Samuelsson et al,[100] *Spinal Cord*, 2004	Assessment of shoulder pain in paraplegic SCI patients using CMS, Wheelchair Users Shoulder Pain Index, and COPM	III	Shoulder pain in this population mostly related to wheelchair activities. No correlation between assessment measures.
Roth et al,[98] *American Journal of Physical Medicine and Rehabilitation*, 2004	Assessment of pain and its relation to affective distress, depression, and pain catastrophizing in patients with chronic wounds/injury	III	McGill pain questionnaire more sensitive to pain in 69 patients (12 with SCI).
Putzke et al,[103] *Spinal Cord*, 2003	Assessment of test-retest reliability of Donovan SCI pain classification	III	Adequate test-retest reliability, interrater agreement low.
Putzke et al,[94] *Spinal Cord*, 2002	Assessment of verbal descriptors to distinguish between pain types after SCI	III	Verbal descriptors of SF-McGill Pain Questionnaire offered marginal utility.
Turner et al,[82] *Pain*, 2002	Assessment of catastrophizing with pain intensity, psychological distress, and pain-related disability in patients with chronic pain after SCI	III	Catastrophizing was strongly and independently associated with poor outcome/disability after SCI.
Richards et al,[104] *Archives of Physical Medicine and Rehabilitation*, 2002	Assessment of Donovan SCI pain classification	III	Considerable variability among raters using the Donovan system to classify SCI pain.
Cardenas et al,[37] *Archives of Physical Medicine and Rehabilitation*, 2002	Evaluation of interrater reliability of Cardenas Pain Classification System, questionnaires, with or without interviews	II	"Substantial" interrater reliability, κ values between 0.66 and 0.68. Interviews did not improve interrater reliability. Small numbers in subgroups prohibit qualitative analysis.

(Continues)

TABLE 3. *Continued*

Reference	Description of Study	Evidence Class	Conclusions
Putzke et al,[95] *Journal of Spinal Cord Medicine*, 2001	Assessment of Short Form-12 to assess pain interference in daily activities	III	Age and occupational status were predictors of pain interference in activities of daily living.
Finnerup et al,[75] *Spinal Cord*, 2001	Questionnaire survey of pain of SCI origin, use of McGill Pain Questionnaire	III	Pain and dysesthesias are common and disruptive consequences after SCI.
Defrin et al,[73] *Pain*, 2001	Characterization of pain and somatosensory function after SCI	III	Damage to the spinothalamic tract is necessary for the occurrence of chronic pain.
Widerstrom-Noga et al,[77] *Arch Phys Med Rehab*, 2001	Questionnaire assessment of chronic pain after SCI, interference with sleep, and activities of daily living	III	Pain of SCI origin interferes with sleep, activities of daily living.
Defrin et al,[72] *Pain*, 1999	Assessment of pain thresholds in patients with chronic pain after SCI	III	Nocioceptive thresholds for pain elevated in patients with complete SCI.
Kennedy et al,[76] *Spinal Cord*, 1997	Analysis of acute and chronic pain after SCI	III	60% of patients with pain from SCI improved in short-term follow-up, 38% improved in long-term follow-up.
Quigley and Veit,[96] *SCI Nursing*, 1996	Use of McGill-Melzack Pain Questionnaire to assess pain of SCI origin	III	McGill-Melzack Pain Questionnaire provides systematic framework for assessment of pain.

[a]CMS, Constant Murley Scale; COPM, Canadian Occupational Performance Measure; IASP, International Association for the Study of Pain; NPSI, Neuropathic Pain Symptom Inventory; SCI, spinal cord injury.

and outdoors subscales ($P < .001$). Their report provides Class I medical evidence on the reliability and validity of SCIM III and the superior sensitivity of SCIM III compared to FIM. Catz et al[65] subjected these data and these results to a stringent Rasch analysis. The authors concluded that the SCIM III subscales were reliable and quantitative (average in-fit mean square indices of 0.79-1.06) as a specific construct of independence after a spinal cord lesion. These 2 publications offer Class I medical evidence in support of the validity, reliability, and sensitivity of SCIM III.[64,65]

Anderson and colleagues[32] reported the consensus analysis of a multinational work group in 2008. Experts in the field of SCI rehabilitation evaluated 4 measures of functional recovery after SCI: the modified Barthel Index, FIM, QIF, and SCIM III. They concluded that the QIF and SCIM III were spinal cord–specific measures of functional abilities and recovery. QIF applies only to tetraplegic patients and has not been widely used or studied. Both FIM and SCIM III were given high consensus marks for validity and reliability. FIM was considered of value in measuring the burden of care; SCIM III was considered the best measure of an individual's global disability specific to an SCI.

In 2009, Rudhe and van Hedel[68] examined the relationship among SCIM III, arm and hand muscle strength, and hand function tests in 29 patients with tetraplegia. They found that SCIM III sum score correlated very well with the sum scores of the 3 tests (Spearman correlation coefficient ≥ 0.76). They concluded that the SCIM III self-care category in particular reflects upper-extremity performance as it contains especially useful and valid items that relate to upper-extremity and capacity tests (Spearman correlation coefficient ≥ 0.80). Their analysis offers Class II medical evidence for the sensitivity, validity, and reliability of SCIM III for tetraplegic patients.

Glass et al[60] published on the applicability of SCIM III to SCI patients in the United Kingdom in 2009. Eighty-six SCI patients were evaluated consecutively over a 12-month period at 4 regional SCI rehabilitation centers. Patients were assessed with SCIM III and with FIM upon admission and within a week of discharge. The Pearson correlation values between SCIM III and FIM scores for each of the 2 raters were 0.798 ($P < .01$) and 0.782 ($P < .01$) respectively, indicating superior validity for both functional assessment tools. The ability to identify a 1-point change within the 4 areas of SCIM III in comparison with the total FIM score was analyzed using the McNemar test. SCIM III detected more numerous changes than FIM in 3 of the 4 subscale areas. The reliability of SCIM III as described by κ coefficients ranged from 0.491 (stair management) to 0.835 (mobility outdoors), indicating moderate (3 tests) to substantial agreement (15 tests). A floor effect was noted for 1 item: transfers ground/wheelchair. The authors concluded that both conventional inferential statistical and Rasch analyses justify the use of SCIM III for assessment of SCI patients and SCI research in the United Kingdom.

Ackerman et al[53] reported the use of SCIM III to assess the functional recovery of 114 patients with complete SCI at the Shepherd Center in Atlanta, Georgia. Their 2010 publication documented statistically significant improvements in SCIM III scores at discharge. The greatest improvements were among C6 and C7-8 injury level patients. The least improvement was observed in the C1-4 and C5 subgroup patients. In the C1-4 injury level patients, a floor effect was observed. Ceiling effects were noted (as expected) for the T1-6 and T7-12 injury level patients because of their fully functional upper extremities upon admission. The authors concluded that despite these modest potential drawbacks owing to injury level, SCIM III is sensitive to changes in individuals with SCI, particularly with injury levels between C5 and T12.

Bluvshtein et al[58] offered their assessment of SCIM III in the evaluation of 261 patients with spinal cord lesions. The results of this multicenter international study were published in 2010. Total agreement between paired raters was > 80% for virtually all SCIM III tasks. The κ coefficients for all SCIM III tasks were all > 0.6 and statistically significant (range, 0.649 to 0.858), indicating substantial to almost perfect agreement. Pearson coefficients of correlation between the paired raters exceeded 0.9, and the interclass correlation coefficients were > 0.95. Cronbach α values for the entire SCIM III scale were 0.833 to 0.835. When compared to FIM, entire SCIM III scores correlated well (r = 0.84, P < .001). SCIM III was more responsive to changes than FIM. In all subscales, SCIM III identified more changes in function than FIM, and in 3 of the 4 subscales, differences in responsiveness were statistically significant (P < .02). The authors concluded that SCIM III is reliable and valid in assessing functional recovery among adult patients with traumatic spinal cord lesions. Their report offers Class I medical evidence on the sensitivity, validity, and reliability of SCIM III for patients with spinal cord lesions.

PAIN ASSOCIATED WITH SCI

Pain following SCI is common. Several reviews and case series suggest that the prevalence of chronic pain after SCI ranges between 25% and 80% of injured patients.[69-78] It has been classified as nocioceptive (musculoskeletal and visceral) and neuropathic (above, at, and below the level of cord injury).[38,70,78,79] There are a variety of psychological and psychosocial factors that interface with the pain of SCI origin that influence its management and treatment.[74,76,80-83] The importance of pain symptoms to patients with SCI cannot be understated. Patients with severe pain syndromes consistently have poor outcome scores in quality of life assessments, have functional impairment beyond that expected from the neurological injury, and often suffer from debilitating depression.[77,84-88] Westgren and Levi[89] have suggested that the impact of pain on quality of life after SCI may be more significant than the original SCI in selected patients.

Thirteen pain intensity instruments have been utilized to assess pain following SCI, including the McGill Pain Questionnaire, the McGill-Melzack Pain Questionnaire, the Zung Pain and Distress Index, the Graded Chronic Pain Disability Scale, the Constant Murley Scale, the Short Form-12, the Multidimensional Pain Inventory, the Brief Pain Inventory of Wisconsin, the Verbal Rating Scale, the Neuropathic Pain Symptom Inventory, the Visual Analog Scale (0-10 points and scales of 0-100 points), the Wheelchair Users Shoulder Pain Index, and an 11-point (0-10 points) Numeric Rating Scale.[36,37,41,69,72,76,77,79,90-101] The Visual Analog Scales have been used most frequently. These instruments use descriptors to categorize pain. Verbal pain descriptors are difficult to apply to the characterization of the different types of pain associated with SCI. For example, the verbal description "burning" can be used by patients to describe nocioceptive and neuropathic pain symptoms, at above and below the level of SCI. Different patients with similar injuries and symptoms may use different verbal descriptors depending on their use of language. These confounding variations and variables hinder the ability of investigators to devise valid and reliable pain intensity instruments.

Five pain classification system instruments have been generated and used as assessment tools for patients following acute SCI: the Tunks SCI pain classification, the Donovan Classification Scheme, the Cardenas pain classification, the Siddall/International Association for the Study of Pain classification, and the Bryce/Ragnarsson SCI pain taxonomy.[37,41,69,70,78,79,84,97,101-104] They are difficult to compare because of varying formats, numbers of items assessed, and different rating scales. Despite these issues, interrater reliability (the degree of agreement between 2 raters using the same pain classification system/instrument to characterize that patient's pain), a means to assess system/instrument validity, has been reported to be "substantial" for 2 of the 5 pain classification systems (κ values between 0.61 and 0.80) (Table 4).[36,37,84]

In 2006, Widerstrom-Noga et al[105] applied a modified version of the Multidimensional Pain Inventory to SCI patients to assess their pain. The Multidimensional Pain Inventory included a means to assess pain severity, physical functioning, and emotional functioning, the 3 key domains "considered important for capturing the multidimensionality of the pain experience." It was brief and easy to administer, and patients felt it was appropriate and applicable. Internal consistency and test-retest reliability were moderate to substantial in 8 of the 10 test

TABLE 4. Pain Assessment[a,b]

SCI Pain Classification System/Instrument*	κ Coefficient
Bryce/Ragnarsson spinal cord injury pain taxonomy	0.70
Cardenas pain classification	0.68
Donovan classification scheme	0.55
Siddall/International Association for the Study of Pain classification	0.49
Tunks spinal cord injury pain classification	0.49

[a]From: Ullrich PM. Pain following spinal cord injury. *Phys Med Rehabil Clin N Am*. 2007;18:217-233.
[b]*SCI, spinal cord injury.*

subscales. Construct validity had high Pearson correlation coefficients in 9 of 10 subscales. The authors concluded that the Multidimensional Pain Inventory is a useful measure for evaluating chronic pain and its impact after SCI.

In 2008, Widerstrom-Noga and additional collaborators[106] developed the International Spinal Cord Injury Pain Data Set to standardize the collection and reporting of pain in the SCI population. It included the 3 essential domains or outcomes of pain severity and physical and emotional functioning. It is meant to evaluate and report the diverse pains in persons affected with SCI. It was designed to be feasible and applicable across varied clinical settings, languages, and countries. It is meant to be used in conjunction with the ASIA impairment scale, which documents the extent of neurological injury following SCI.

Jensen et al[107] in 2010 reported the use of the Spinal Cord Injury Basic Pain Data Set (ISCIBPDS) among 184 SCI patients with pain. The internal consistency of the data set (as an indicator of reliability) was excellent (Cronbach $\alpha = 94$). The validity of the ISCIBPDS was statistically significant at the $P < .001$ level for 23 of the 27 pain interference items and scales and was statistically significant at the $P < .01$ level for 26 of the 27 pain interference items and scales. The authors concluded that the ISCIBPDS is useful and valid as a self-report means for assessing pain and its impact in individuals with SCI. Their report provides Class I medical evidence on the utility of the ISCIBPDS to assess pain of SCI origin and is recommended for use in both the clinical and research settings.

SUMMARY

A variety of injury classification schemes have been utilized to describe patients who have sustained spinal cord injuries. There are 2 general types of assessment scales, neurological examination scales and functional outcome scales. The most accurate and meaningful description of SCI patients, in the acute setting and in longitudinal follow-up, is that accomplished by using a neurological scale in conjunction with a functional outcome scale. Based on a contemporary evaluation and ranking of the medical evidence, the 2000 American Spinal Injury Association (ASIA) Standards is the most consistent, reliable, valid, and responsive scoring system for the neurological assessment of adult patients with acute SCI, to a high degree of scientific certainty. This recommendation is supported by Class II medical evidence.

The SCIM III, designed specifically to assess the functional abilities and impairment of patients with spinal cord lesions and SCI, is the functional outcome assessment tool with the greatest scientific validity, reliability, and sensitivity. This recommendation is supported by Class I medical evidence.

The assessment of pain among patients with SCI is important and should include an evaluation of pain severity, physical functioning, and emotional functioning. There are a number of pain assessment classification instruments that have been used in this patient population. The ISCIBPDS has the highest reliability and validity of any of the pain classification instruments and is recommended on the basis of Class I medical evidence.

KEY ISSUES FOR FUTURE INVESTIGATION

Clinical trials in which all 3 clinical assessment parameters (neurological examination, functional outcome assessment and pain assessment) are studied as an integral part of outcome measurements are needed to more completely describe the clinical status of patients following acute SCIs.

Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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