CLINCAL ASSESSMENT FOLLOWING ACUTE CERVICAL SPINAL CORD INJURY

RECOMMENDATIONS

Neurological Examination:

Standards: There is insufficient evidence to support neurological examination standards.

Guidelines: There is insufficient evidence to support neurological examination guidelines.

Options: The ASIA international standards for neurological and functional classification of spinal cord injury is recommended as the preferred neurological examination tool for clinicians involved in the assessment and care of acute spinal cord injury patients.

Functional Outcome Assessment

Standards: There is insufficient evidence to support functional outcome assessment standards.

Guidelines: The Functional Independence Measure (FIM) is recommended as the functional outcome assessment tool for clinicians involved in the assessment and care of acute spinal cord injury patients.

Options: The modified Barthel Index (MBI) is recommended as a functional outcome assessment tool for clinicians involved in the assessment and care of acute spinal cord injury patients.

RATIONALE

Acute traumatic spinal cord injury affects 12,000 to 14,000 people in North America each year. The functional consequences of an acute spinal cord injury (ASCI) are variable, therefore

the initial clinical presentation of patients with ASCI is a key factor in determining triage and therapy and predicting prognosis. Consistent and reproducible neurological assessment scales are necessary to define the acute injury patient's neurological deficits and to facilitate communication about patient status to caregivers. Prognostic information provided by comparing injury victims to the outcomes of historical patients with similar injuries is of value to patients and families. The evaluation of new therapies proposed for the treatment of ASCI require the use of accurate, reproducible neurological assessment scales and reliable functional outcome measurement tools, not only to measure potential improvement following therapy, but to determine its functional significance. For these reasons, the clinical neurological assessment and the determination of functional abilities are important aspects of the care of patients with ASCI. The purpose of this review of the medical literature is to determine which neurological assessment scales and which functional impairment tools have the greatest utility in the care of patients with acute spinal cord injuries.

SEARCH CRITERIA

A computerized search of the database of the National Library of Medicine of the literature published from 1966 to 2001 was performed. The search was limited to the English language and the human literature. The terms "spinal cord injury" or "spinal injury" were combined with the terms "classification or assessment", yielding 17,923 references. Another search using the terms "scale" or "weights and measures" or "index" or "abstracting and indexing" combined with the terms "spinal cord injury" or "spinal injury" yielded 337 references. These 337 references and the previous 17,923 references from the broader search were imported into a database and duplicates were eliminated. Papers germane to this topic 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.

A total of fifty-three articles were accessed, reviewed, graded, and included in this review. There is no Class I medical evidence in the literature on this topic. There are two Class II comparative analyses of functional outcome scales. Twenty-seven pertinent manuscripts are summarized in Evidentiary Table format.

SCIENTIFIC FOUNDATION

A variety of assessment systems are available for the documentation of neurological status of patients following ASCI. They include the Frankel Scale, the modified Frankel Scale, Lucas and Ducker's Neurotrauma Motor Index, the Sunnybrook, the Botsford, and the Yale scales, the NASCIS scale, the ASIA scale and the ASIA/International Medical Society of Paraplegia international standards for neurological and functional classification of spinal cord injury scale.(1-4,6-10,13,15,16,28,37,41,47)

Several of these assessment scales have been refined through serial iterations.(1-4,28,41,42,47) 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. Finally, there must be measurement 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. Whatever assessment system is used it must

have inter-rater 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 spinal cord injury 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 two general types. The first type is exam 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.(1-2,6-12,15,28,37,41,47) The second type of scale focuses on functional skills, including a patient's ability to care for his or her self, participate in personal hygiene, transfer or ambulate.(3-4,14,22-24,26,29,34-35,38,42,45) 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. More contemporary assessment scales incorporate both neurological examination scores and functional outcome scores in their overall definition of individual patients.(3,4,51)

Neurological Examination scales

Frankel et al provided the first report of a stratified neurological scale employed to characterize patients with acute traumatic spinal cord injuries in 1969.(28) The authors used a five grade scale, A to E, to define spinal cord injuries in 682 patients managed at the Stoke Mandeville Hospital between 1951 and 1968. Grade A patients had complete motor and sensory lesions, Grade B patients had sensory only function below the level of injury. Grade C patients

had motor and sensory function below the level of injury but the motor function was useless. Grade D patients had motor useful, but not normal function below the level of spinal cord injury and Grade E patients had recovery, no motor, sensory or sphincter disturbance. The Frankel scale, as it became known, was widely adopted for use in the description of spinal cord injury patients and in assessment of their therapy (outcome) in the 1970's and 1980's.(1,2,28,29,41) It was easy to use, was based solely upon motor and sensory function and required very little patient assessment before classification into one of five grades. However, differentiation between patients classified into grades C and D was imprecise. These were broad injury groups with considerable range within each injury grade. The sensitivity of the Frankel scale to change in serial measurements, particularly among patients in grades C and D was poor. Significant improvement in patient function could occur over time without the patient advancing a Frankel grade.(1,2,7) Modifications of the Frankel scale were offered in an attempt to solve this shortcoming, however, the use of the Frankel scale as either an acute assessment tool or an outcome measure has been largely abandoned due to its lack of sensitivity. (3,4,6,7,13,20,42,47,48,50,51)

Institutions and investigators have proposed a variety of neurological assessment scales for spinal cord injury patients over the years. (1-4,6-12,15,28,37,41,47) In 1978, Bracken et al described the spinal cord injury severity scale developed at Yale University School of Medicine.(8) This scale combines motor and sensory function in selected muscle groups and dermatomes. Its primary focus is to distinguish between complete and incomplete spinal cord injuries. The sensory severity scale ranged from one point to seven points, and the motor severity scale ranged from one point to five points. The authors reported a strong correlation between the two scales and noted that "change scores" in motor and sensory function correlated

with outcome at discharge compared to admission. Their proposed assessment scales did not assess bowel or bladder function and suffered from grouping all patients into one of five possible motor scales and into one of seven possible sensory scales. It was difficult to memorize and hard to apply at the bedside.

In 1979, Lucas and Ducker at the Maryland Institute for Emergency Medical Services (MIEMS) developed a scoring system for patients with ASCI.(37) Their scale was based on motor function at and below the level of injury (Lucas and Ducker's Neurotrauma Motor Index), and was used to evaluate over 800 patients collected by the Nationwide Spinal Cord Injury Registry. It was later modified for a prospective study of spinal cord injury treatment regimes employed at MIEMS. The authors chose 14 muscles for examination and used mathematical analysis to predict a motor outcome score based upon the initial motor examination and an empirically derived understanding of the recovery rate of individual injury subtypes. The scoring system was limited in that many patients were excluded from the analysis (only 436 of over 800 patients were analyzed), the standard error of the predicted recovery score was large, and the calculations were cumbersome. Their scoring system was later modified by the American spinal Cord Injury Association (ASIA) into a motor index score.(23,42)

In the early eighties three different SCI neurological assessment scales were introduced, not one of which gained popular acceptance. (15,34,47). In 1980, Klose et al described the University of Miami Neuro-Spinal Index (UMNI).(34) It was composed of two sub-scales, one motor and the other sensory. The motor scale was scored on a zero to five-point scale for 44 muscle groups, resulting in a possible range of scores from zero to 220. Sensory scoring was a three-point scale for pinprick and vibratory sensation in 30 dermatomes on each side of the body. Initial inter-rater reliability was high among three physical therapists that examined ten

neurologically stable patients in the rehabilitation setting. Further studies were planned to determine the efficacy of UMNI in the acute setting and as an outcome tool. The Yale Scale was reported in 1981 by Cherazi et al at the Yale New Haven Medical Center.(15) The scale employed the British Medical Research Council's (BMRC) gradation (zero to five points) of muscle strength using 10 selected muscle groups from each side of the body. Sensory function was scored on a zero to two-point scale for superficial pain, position sense and deep pain. Bladder and bowel functions were not scored. In 1982, the Sunnybrook Cord Injury Scales for assessing neurological injury and recovery from spinal cord injury were proposed by Tator et al. (47) A ten point numerical neurological assessment scale was offered. It represented an improvement upon the Frankel scale in how sensory losses were classified. However, like the Frankel scale, motor grading was not very sensitive. The differentiation between grades three to five and grades six to eight that corresponded to Frankel grades C and D remained relatively imprecise and consisted of large, heterogeneous groups of patients. Bladder and bowel functions were not assessed.

In 1984, the American Spinal Injury Association (ASIA) generated standards for the neurological classification of spinal injury patients.(1) The neurological assessment used a ten-muscle group motor index score (zero to five points scale) and incorporated the Frankel classification as the functional abilities assessment tool. The sensory examination was not scored but the most cephalad level of normal sensation was noted. These standards were revised in 1989 to provide better, more specific sensory level determinations.(2) In 1991, Priebe and Waring examined the inter-observer reliability of the revised ASIA standards (1989 version).(44) Sample patients in quiz format were given to house-staff and faculty of a department of Physical Medicine and Rehabilitation. They were asked to classify each patient with respect to sensory

level, motor level, zone of injury and Frankel classification according to the 1984 ASIA standards. Two months later they were asked to complete another quiz using the 1989 ASIA standards. While the percent correct answers improved using the 1989 ASIA standards the authors conclude that inter-observer reliability was "less than optimal" with a kappa coefficient of 0.67, indicating agreement between observers but only within the range of fair agreement.(44)

Botsford et al introduced a new functionally oriented neurological grading system that incorporated motor and sensory function, rectal tone and bladder control.(7) The motor assessment scored on a zero to five-point scale assessed flexor and extensor groups at major joints (hence a "more functional" motor assessment). Sensory function was graded on a zero to ten-point scale and was divided into five categories. Voluntary rectal contraction was scored on a ten-point scale (zero, five or ten points). Bladder function was dived into normal and not normal and assigned 5 points. The authors applied their proposed grading system to a historical group of patients who had initially been assessed and classified according to the Frankel scale. They concluded that the new grading system was more sensitive for the detection of improvement in the neurological examination and in functional performance over time.(7)

Two national acute spinal cord injury studies (NASCIS I and II) were accomplished in the late 1980's and early 1990's in examination of methylprednisolone as a treatment for patients with acute spinal cord injuries.(9-12) Investigators at multiple centers in North America used a motor assessment scale (NASCIS scale) that evaluated motor function in fourteen muscle groups graded from one point to six points (NASCIS I),(9-10) or zero to five points (NASCIS II).(11-12) Scores for the right and left sides of the body were obtained independently. Sensory function was divided into pin-prick and light touch in dermatomes C2 through S5 and was scored on a zero to three-point scale. Functional abilities were not assessed in the NASCIS I and II

studies. Like most other neurological assessment scoring systems before the NASCIS scales, there was no documentation of inter-observer reliability, despite the large numbers of patients examined and entered into the NASCIS I and II trials.

In 1992, ASIA generated new standards for neurological and functional classification of spinal cord injury in conjunction with the International Medical Society of Paraplegia (IMSOP).(3) These standards replaced the revised 1989 version. The new assessment recommendations included motor index scores, sensory examination scores (zero to two point scale), the ASIA impairment scale (modified Frankel classification) and incorporated the Functional Independence Measure (FIM). FIM is a functional assessment tool and is used to assess the impact of SCI on the patient's functional abilities. It quantifies the extent of individual disability and complements the neurological assessment by providing scoring for activities of eating, grooming, bathing, dressing upper body, dressing lower body and toileting. (20-23) Improvements in neurological function over time or with treatment (as documented by neurological examination scales) can be measured in terms of functional or meaningful improvement to the patients with the addition of FIM in the assessment battery.

Davis et al measured the inter-rater reliability of Frankel classification and the Sunnybrook scale by experienced personnel who were provided with concise definitions.(19) They demonstrated high inter-rater reliability of the Frankel classification and Sunnybrook scales (Pearson correlation coefficients 0.71 to 0.91), with 94% to 100% intra-rater agreement. Kappa values were not provided. The authors concluded that both assessment systems corresponded well to total sensory and motor function in SCI patients but were insensitive to ambulation skills and bladder function.(19)

In 1993, Bednarczyk and Sanderson reported on the ability of three different classification systems to describe spinal cord injury patients and to compare the correlation between the three scales when provided by a single trained provider.(5) They compared the NASCIS scale with the ASIA scale and the BB (wheelchair basketball) Sports Test. The authors found that that the ASIA scale had the greatest discrimination in grouping subjects with SCI into mixed injury categories and into incomplete injury categories. The BB Sports Test had a positive correlation with the ASIA scale (Spearman's rho correlation coefficient, 0.81). The NASCIS scale had a negative correlation with both the ASIA scale (-0.66) and the BB Sports Test (-0.48). In contrast, El Masry et al retrospectively assessed 62 consecutive ASCI patients and compared ASIA and NASCIS motor scores with conventional motor examinations. They found that both motor assessment scales were representative of the conventional motor scores reported for these patients and could be used to quantify motor deficits and recovery following ASCI.(26)

Lazar et al, in 1989, evaluated the relationship between early motor status and functional outcome after SCI prospectively in 52 quadriplegic and 26 paraplegic patients.(36) Motor status was measured within 72 hours of injury and quantified with the ASIA motor index score (MIS). Functional status was evaluated with the modified Barthel index (MBI). A senior physical therapist completed MIS and MBI assessments on each patient upon admission to the spinal cord intensive care unit and every 30 days during rehabilitation. The authors found that early motor function correlated well with average daily improvement in functional status including self-care and mobility ($p = .001$). The initial MIS strongly correlated with the functional status of quadriplegics at admission ($p = .001$), at 60 days, and at rehabilitation discharge ($p = .001$), but had poor correlation in paraplegic patients. The MIS correlated significantly with the MBI self-care sub-score at 60 days and at discharge ($p = .01$), but not with the MBI mobility sub-score.

They concluded that the MIS a useful tool in predicting function during rehabilitation, although individual differences in ambulation, particularly for patients with paraplegia, limit the predictive utility of this index.(36)

Waters et al, in 1994, compared the strength of 36 acute SCI patients as determined by the ASIA motor score with motor scores based on biomechanical aspects of walking to predict ambulatory performance.(49) The authors found that the ASIA scoring system compared favorably with the biomechanical scoring system, and was a relatively simple clinical measure that correlated strongly with walking ability. In 1995, Marino et al compared the ASIA motor level (ML) and the upper extremity motor score (UEMS) to the neurological level (NL) of injury in fifty quadriplegics.(40) At 12 months post-injury, Quadriplegia Index of Function (QIF) assessments were obtained. Spearman's correlations were calculated. The authors found that the ML was more highly correlated to the UEMS and the QIF than the NL. The UEMS had the highest correlation to the QIF feeding score, 0.78. They concluded that the ASIA ML and UEMS better reflect the severity of impairment and disability. Similarly, Ota et al compared the ASIA motor scores and neurological level of injury (NL) with FIM in 100 Frankel grade A and B patients. They found that the motor score reflected the patients' disability as determined by FIM better than the ASIA level of injury. (43)

Wells and Nicosia compared the utility and limitations of five different spinal cord injury scoring systems applied by a single skilled observer in the assessment of 35 consecutive SCI patients; the Frankel classification, the Yale Scale, the ASIA motor index score, the Modified Barthel Index (MBI) and FIM scores.(51) The authors found that the Frankel classification correlated strongly with the Yale scale and the ASIA motor index scores but poorly with MBI and FIM. These three assessment scales shared a focus on impairment measurement. The MBI

and the FIM score correlated strongly, but weakly with the other scales and shared a focus on disability. They concluded that one classification system or scale alone does not adequately describe SCI patients in both the acute and follow-up settings. They favored a combination of two scales to characterize ASCI patients, one based on neurological impairment and the other on functional disability.(51)

Jonsson et al, evaluated inter-observer reliability of the 1992 ASIA standards for neurological and functional classification of spinal cord injury.(33) Two physicians and two physiotherapists classified 23 SCI patients according to the 1992 recommendations. Kappa values for pin-prick scores varied from 0 to 0.83 (poor to very good), from 0 to 1.0 for light touch scores and from 0 to 0.89 for motor function. They found weak inter-rater reliability for scoring patients with incomplete spinal cord injuries. Cohen et al performed further tests of reliability of the 1992 ASIA standards.(17) One hundred and six professionals in the field of SCI completed a pretest and posttest in which they classified two SCI patients by sensory and motor levels, zone of partial preservation (ZPP), ASIA impairment scale and completeness of injury. Percent 'correct' was calculated for each tested criterion. The authors reported that participants had very little difficulty in correctly classifying the patient with a complete SCI but had variable success characterizing the patient with an incomplete SCI. They concluded that further refinement of the 1992 ASIA standards and more training in their application was required.(17)

In 1996, ASIA/IMSOP provided a revised version of the international standards for neurological and functional classification of spinal injury (an update of their 1992 recommendations).(4) Further refined by input from numerous international organizations, the combination of the ASIA impairment scale, the ASIA motor index score, the ASIA sensory scale

and FIM is considered to be the most representative assessment and classification tool for patients with acute spinal cord injuries. It was felt to be an improvement on the pre-existing 1992 standards, which were subject to criticism.(4,13,17,18,25,33,42-44)

Functional outcome scales

Functional outcome scales are nonspecific measures of human performance ability relevant to medical rehabilitation, that is, how a person functions with activities of everyday life. Several scales have been developed in an effort to accurately characterize an injury victim's functional skills and disabilities in order to quantify his or her functional independence.(3,4,14,20,22,24,25,27,29,30,34,35,38,39,42,43,45,46) They attempt to determine a patient's ability or inability to live independently. Scales for functional rating include, the Barthel Index (BI), Modified Barthel Index (MBI), the Functional Independence Measure (FIM), the Quadriplegic index of Function (QIF), the spinal cord independence measure (SCIM), the Walking Index for spinal cord injury (WISCI), and the spinal cord injury functional ambulation inventory (SCI-FAI). (3,4,14,20,22,24,25,27,29,30,34,35,38,39,42,43,45,46) They are applicable to a wide range of nervous system disorders, however the QIF, the SCI-FAI and the SCIM are more specific for patients with SCI.(14,27,29) All of these scales have been successfully used to characterize to SCI patients. (3,4,14,20,22,24,25,27,29,30,34,35,38,39,42, 43,45,46)

Among many available functional assessment scales, the BI has been one of the most popular.(35,38,52) It has been utilized for both the characterization of individual patients, and in the evaluation of the efficacy of various rehabilitation programs. The BI has ten ratable patient skill items. Values are assigned to each item (zero, five points or ten points) based on the amount of physical assistance required to perform each task. A BI total score ranges from zero

to 100 points (0: fully dependent; 100: fully independent). In the original version, each item is scored in three steps.(38) The modified Barthel Index (MBI) with a five-step scoring system, appears to have greater sensitivity and improved reliability than the original version, without examination difficulty or an increase in implementation time. Shaw et al found the internal consistency reliability coefficient for the MBI to be 0.90, compared to 0.87 for the original index.(45) In another study, Kucukdeveci et al, evaluated the reliability and validity of the MBI in 50 inpatient rehabilitation SCI patients in Turkey.(35) Patients were assessed by the MBI at admission and discharge. Reliability was tested using internal consistency, inter-rater reliability and the intra-class correlation coefficient. Construct validity was assessed by association with impairments (ASIA) and by Rasch analysis. Internal consistency was 0.88. The level of agreement between two raters was sufficient with Kappa levels of 0.5. The intra-class correlation coefficient was 0.77. However, Rasch analysis revealed that bladder and bowel items of the MBI misfit the construct. The authors concluded that adaptation of the modified Barthel Index is useful in assessment of SCI patients in Turkey as long as its limitations are recognized.(35)

The FIM was developed to provide uniform assessment of severity of patient disability and medical rehabilitation outcome.(20-23) It is an 18-item, 7-level scale designed to assess severity of patient disability, estimate burden of care and determine medical rehabilitation functional outcome. The FIM has emerged as a standard assessment instrument for use in rehabilitation programs for disabled persons.(4,20-23,25,30-32,42,43,51,53) In 1993, Dodds et al assessed FIM with respect to validity and reliability in characterizing 11,102 general rehabilitation patients in the Uniform Data System from the Pacific Northwest.(25) They compared admission and discharge FIM scores and assessed for validation using several

hypotheses. The authors found high overall internal consistency and that FIM identified significant functional gains in patients over time. FIM discriminated patients on the basis of age, comorbidity, and discharge destination. The authors concluded that FIM had high internal consistency, adequate discriminative capabilities and was a good indicator of burden of care.(25)

Hamilton et al have assessed inter-rater agreement of the seven-level FIM in two separate reports (31,32). In the 1991 report, two or more pairs of clinicians assessed each of 263 patients undergoing inpatient medical rehabilitation at 21 US hospitals subscribing to the uniform data system (UDS) for medical rehabilitation.(31) Criteria were intra-class correlation coefficient (ICC) (ANOVA) for total FIM, and FIM sub-scores greater than or equal to 0.90 (five of six sub-scores must be .90 or more; no ICC could be 0.75 or less). Kappa values (unweighted) for individual FIM items had to be greater than or equal to 0.45 for at least 15 of the 18 items. The total FIM ICC was 0.97. Sub-score ICC's were: self-care; 0.96, sphincter control; 0.94, mobility (transfers); 0.96, locomotion; 0.93, communications; 0.95 and social cognition; 0.94. The FIM item Kappa mean was 0.71, (range 0.61 to 0.76). The authors concluded that the 7- level FIM appears to have good clinical inter-rater agreement based on their methods of analysis.(28) In 1994, Hamilton et al reported inter-rater reliability among clinicians from 89 US rehabilitation facilities within the UDS. One thousand eighteen patients were characterized.(32) Using similar analysis methods reported earlier, total FIM ICC was 0.96. Sub-score ICC's ranged from 0.89 to 0.96. FIM item Kappa coefficients ranged from 0.53 to 0.66. For a subset of institutions that met UDS reliability criteria, kappa values ranged from 0.69 to 0.84. The authors concluded that FIM is reliable when used by trained and tested inpatient medical rehabilitation clinicians. Stineman et al utilized the FIM instrument and a function-based strategy to generate functional outcome benchmarks among 3604 spinal cord injury patients they reviewed.(46) They found

that the majority of patients whose motor-FIM scores at admission were above 30 were able to groom, dress the upper extremity, manage bladder function, use a wheelchair and transfer from bed to chair by the time of discharge from rehabilitation. Most patients with scores above 52 attained independence in all but the most difficult FIM tasks such as bathing, tub transfers and stair climbing. The authors concluded that these "FIM item attainment benchmarks" may be useful in counseling patients, predicting outcome and anticipating post-discharge patient care needs.

The Quadriplegia Index of Function (QIF) was developed in 1980 because the Barthel Index was deemed too insensitive to document the small but significant functional gains made by quadriplegics (tetraplegics) during medical rehabilitation.(29,53) The QIF is comprised of variables that are each weighted and scored (transfers, grooming, bathing, feeding, dressing, wheelchair mobility, bed activities, bladder and bowel program and understanding of personal care). A final score ranging from zero to 100 points is derived that characterizes each patient's functional abilities and serves as a reference for future assessment. Gresham et al tested the QIF on a group of 30 complete quadriplegic patients at admission to and discharge from inpatient medical rehabilitation.(29) Resultant scores were compared to those simultaneously obtained by the Barthel Index and the Kenny Self-Care Evaluation (KSCE). The QIF was found to be more sensitive for patient functional improvement (46%) than that defined by the BI (20%) or the KSCE (30%). The QIF was also tested for reliability. Ratings by three different nurses, working independently, were found to be significantly positively correlated for all sub-scores ($p<.001$). Gresham et al concluded that the QIF provides a useful option in choosing a functional assessment instrument for quadriplegic patients.(29)

Yavuz et al compared ASIA scores, the QIF and FIM in twenty-nine subjects with cervical SCI.(53) The same examiner used all three scales at admission to and discharge from the rehabilitation center. They identified strong correlation of ASIA scores to both FIM and the QIF. Feeding and dressing categories of QIF showed an even stronger correlation to ASIA motor scores, however statistical significance was the same for corresponding categories of FIM and QIF. The percent of recovery on ASIA motor scores was significantly correlated only to gain in QIF scores, not FIM. The authors recommended that additions to the FIM may be useful, especially in the feeding, dressing and bed activity categories in order to improve sensitivity.(53)

Catz et al developed a new disability scale specific for patients with spinal cord pathology, SCIM and compared it to FIM in the assessment and characterization of 30 patients. (14) Two pairs of trained staff members recorded scores one week after admission and every month thereafter during hospitalization. The authors found remarkable consistency between each pair of raters for all tasks assessed, Kappa coefficient between 0.66 and 0.98. The authors found the SCIM more sensitive than FIM to changes in function of spinal cord lesion patients: SCIM detected all functional changes detected by FIM, but FIM missed 26% of changes detected by SCIM scoring. The authors concluded that SCIM may be a useful instrument for assessing functional changes in patients with lesions of the spinal cord.

The Walking index for SCI (WISCI) was proposed as a scale to measure functional limitations in walking of patients following SCI.(24) It incorporates gradations of physical assistance and devices required for walking following paralysis of the lower extremities secondary to SCI. The purpose of the WISCI is to document changes in functional capacity with respect to ambulation in a rehabilitation setting. A pilot study of the WISCI was completed utilizing video clips of patients walking. Raters at eight international centers completed the

assessment skills. The concordance for the pilot data was significant. Inter-rater reliability revealed 100% agreement. The authors conclude that the WISCI showed good validity and reliability but needed further evaluation before it can serve as a useful tool for clinical studies. (24)

Finally, the SCI-FAI is a functional observational gait assessment instrument developed at the University of Miami that addresses three key domains of walking function in individuals with SCI: gait parameters/symmetry, assistive device use and temporal-distance measures.(27) The authors assessed its validity and reliability in a study of 22 patients with incomplete spinal cord injuries examined by four trained raters. Inter-rater reliability was good for all four raters, ICC range = 0.850 to 0.960. A moderate correlation (Pearson r = 0.58) was found between change in gait score and lower extremity strength. The authors concluded that the SCI-FAI is a reliable, valid and relatively sensitive measure of walking ability in individuals with SCI.

SUMMARY

A variety of injury classification schemes have been utilized to describe patients who have sustained spinal cord injuries. There are two general types of assessment scales, neurological examination scales and functional outcome scales. The most accurate and meaningful description of spinal cord injury patients, in the acute setting and in follow-up, appears to be that accomplished by using a neurological scale in conjunction with a functional outcome scale. At present, the most utilized and studied neurological assessment scales are the ASIA scores including the motor index scores, sensory scores and the ASIA Impairment scale. After multiple revisions and several refinements these scales are easy to apply, and are reliable.

The 1996 ASIA recommendations for international standards of neurological and functional classification of spinal cord injury include the ASIA scales, as noted, and the

Functional Independence Measure (FIM). FIM as a functional outcome tool has been studied extensively. It appears to be the best functional outcome scale used to describe disability among SCI patients, both early and late after injury. It is easy to administer and is valid and reliable. Inter-rater agreement with FIM has been high in several studies with reported Kappa values of 0.53 to 0.76.

KEY ISSUES FOR FUTURE INVESTIGATION

Any future investigation of or clinical trial involving spinal cord injury patients must include both a neurological examination scale and a functional outcome assessment. Therapeutic trials of spinal cord injury patients should include reliable neurological and functional scoring systems and should verify the validity and inter-rater reliability of those scoring scales as part of the investigational paradigm.

EVIDENTIARY TABLE: Neurological Examination Scales

First Author Reference	Description of Study	Data Class	Conclusions
Jonsson, 2000, *Spinal Cord*	A study of the inter-rater reliability of the ASIA ISCSCI-92. Physicians and physiotherapists classified 23 patients according to the ISCSCI-92 and calculated Kappa values.	Class III	This study indicates a weak inter-rater reliability for scoring incomplete SCI lesions using the 1992 ASIA standards.
Cohen. 1998, *Spinal Cord*	This study was a test of the ASIA ISCSCI-92. Participants completed a pretest and posttest in which they classified two patients who had a SCI.	Class III	Further revision of the ASIA 1992 standards and more training was needed to ensure accurate classification of spinal cord injury.
El Masry, 1996, *Spine*	A study to assess the reliability of the ASIA and NASCIS motor scores. The motor scores of 62 consecutive acute SCI patients were retrospectively reviewed.	Class III	The differences in correlation coefficients between the ASIA motor score and the NASCIS motor score were not statistically significant. The ASIA and NASCIS motor scores can both be used for the neurological quantification of motor deficit and motor recovery.
Wells, 1995, *J Spinal Cord Med*	A comparison of the Frankel Scale, Yale Scale, Motor Index Score, MBI, Functional Independence Measurement (FIM) in 35 consecutive acute SCI patients.	Class III	The best assessment tool is a combination of two scales, one based on neurological impairment and the other on functional disability.
Waters, 1994, *Arch Phys Med Rehab*	An assessment of strength using motor scores derived from ASIA compared with motor scores based on biomechanical aspects of walking in predicting ambulatory performance in 36 SCI patients.	Class III	The ASIA scoring system compared favorably with the biomechanical scoring system. ASIA motor score strongly correlates with walking ability.
Davis, 1993, *Spine*	A prospective study of 665 acute SCI patients to determine the reliability of the Frankel and Sunnybrook scales.	Class III	Demonstrated high inter-rater reliability of Frankel and Sunnybrook scales. Both scales correspond to total sensory and motor function but are insensitive to walking and bladder function.
Bednarczyk, 1993, *J Rehab Research & Dev*	A study comparing ASIA scale, NASCIS scale and wheelchair basketball (BB) Sports Test in 30 SCI patients classified by the same examiner.	Class III	ASIA Scale showed the greatest discrimination in grouping subjects with ASCI. NASCIS scale had negative correlation with ASIA scale and BB sports test.
Botsford, 1992, *Orthopedics*	Description of a new functionally oriented scale with assessment of motor and sensory function, rectal tone and bladder function.	Class III	Botsford scale was sensitive for the detection of improvement in function over time following SCI.

First Author Reference	Description of Study	Data Class	Conclusions
Priebe, 1991, *Am J Phys Med & Rehab*	A study of the interobserver reliability of the 1989 revised ASIA standards assessed by quiz given to 15 physicians.	Class III	The interobserver reliability for the revised ASIA (1989) standards were improved compared to previous versions, but less than optimal. Changes were recommended.
Bracken, 1990 *New England Journal of Med*	Multi-center North American trial examining effects of methylprednisolone or naloxone in ASCI. (NASCIS II)	Class III for neurological assessment	Motor scores of 14 muscles on 0-5 point scale, right side of body only. Sensory scores of pin prick and light touch, 1-3 point scale, bilateral. No inter-rater reliability comparison.
Lazar, 1989, *Arch Phys Med & Rehab*	A prospective study of the relationship between early motor status and functional outcome after SCI in 78 patients. Motor status was measured by the ASIA Motor Index Score and functional status was evaluated with the Modified Barthel Index.	Class III	The MIS correlated well with functional status for quadriplegic patients, poorly for paraplegic patients. Individual differences in ambulation limit its predictive utility.
Bracken, 1985 *J Neurosurg*	Multi-center North American trial examining effects of methylprednisolone in ASCI. (NASCIS I)	Class III for neurological assessment	Motor scores of 14 muscles on 1-6 point scale. Right side of body only. Sensory scores of pinprick and light touch, 1-3 point scale, bilateral. No inter-rater reliability comparison.
Tator, 1982, *Early Management of Spinal Cord Injury*	Initial description of the Sunnybrook Scale, a 10 grade numerical neurological assessment scale.	Class III	Improvement from the Frankel scale. Motor grading subdivided but not very sensitive.
Cherazi, 1981, *J Neurosurg*	Initial description of the Yale scale and its use in a group of 37 patients with SCI.	Class III	Provides assessment of the severity of SCI.
Lucas, 1979, *American Surgeon*	Initial description of a motor classification of patients with SCI and its use in 800 patients.	Class III	Allows the clinical researcher to evaluate current treatments and assess the potential of new treatment regimes.
Bracken, 1977 *Paraplegia*	Description of 133 ASCI patients classified using motor and sensory scales developed by Yale Spinal Cord Injury Study Group.	Class III	Considerable discrepancy between motor and sensory impairment scales among patients with greater motor than sensory loss.
Frankel, 1969 *Paraplegia*	The first clinical study of the Frankel scale to assess neurologic recovery in 682 patients treated with postural reduction of spinal fractures.	Class III	First neurological examination scale for ASCI.

EVIDENTIARY TABLE: Functional Outcome Scales

First Author Reference	Description of Study	Data Class	Conclusions
Field-Fote, 2001, *J Rehabil Med*	SCI-FAI offered as functional assessment scale for gait assessment.	Class III	Reliable and relatively sensitive measure of walking ability in patients with SCI. Interrater reliability good. No kappa values offered.
Kucukdeveci, 2000, *Scan J of Rehab Med*	To determine the reliability and validity of the MBI in Turkey.	Class III	Adaptation of the modified Barthel Index successful in Turkey as long as its limitations are recognized. Kappa values > 0.5.
Ditunno, 2000, *Spinal Cord*	WISCI offered as index for ambulation skills following SCI in pilot study.	Class III	Good reliability, excellent interrater reliability but needs assessment in clinical settings.
Yavuz, 1998, *Spinal Cord*	Assessment of the relationship of two functional tests, FIM and QIF, to ASIA scores.	Class III	Strong correlation between FIM and QIF to ASIA scores.
Catz, 1997, Spinal Cord	SCIM offered as new disability scale for spinal cord lesions. Thirty patients assessed with SCIM and FIM.	Class III	SCIM more sensitive than FIM.
Hamilton, 1994, *Scan J of Rehab Med*	Assessment of interrater agreement of FIM in 1018 patients in 89 UDS hospitals.	Class II	Kappa values for 7 level FIM ranged from 0.53 to 0.66. Kappa values higher in subset of UDS hospitals with experienced rehab clinicians, 0.69 to 0.84.
Dodds, 1993 *Arch Phys Med Rehabil*	Assessment of reliability of FIM in characterizing 11,102 UDS rehab patients.	Class III	FIM has high internal consistency, adequate discriminative capabilities, and was good indicator of burden of care.
Hamilton, 1991, *Arch Phys Med Rehabil*	Interrater agreement assessment of FIM in 263 patients in 21 UDS hospitals.	Class II	Kappa values for 7 level FIM ranged from 0.61 to 0.76, mean 0.71.
Shah, 1989, *Journal of Clin Epidemiology*	Description of Modified Barthel Index (MBI).	Class III	The MBI has greater sensitivity and improved reliability than the original version, without additional difficulty or implementation time.
Gresham, 1986 *Paraplegia*	Assessment of QIF as functional scale, compared to Barthel Index.	Class III	The QIF was more sensitive and reliable than the Barthel Index.

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