

ORIGINAL ARTICLE

# Can spinal cord injury patients show a worsening in ASIA impairment scale classification despite actually having neurological improvement? The limitation of ASIA Impairment Scale Classification

This article has been corrected since Advance Online Publication and a corrigendum is also printed in this issue.

İ Gündoğdu<sup>1</sup>, M Akyüz<sup>2</sup>, EA Öztürk<sup>1</sup> and FA Çakıcı<sup>1</sup>

**Background:** In our clinical training program, which includes probable American Spinal Injury Association impairment scale (AIS) grade changes in the event of recovery, we have noticed some confounding results regarding the AIS grading in spinal cord injury (SCI) patient case examples who are expected to recover. We also observed an individual case that showed a conflict between AIS grade conversion and neurological changes in European Multicenter Study on Human Spinal Cord Injury study.

**Study design:** The analysis of SCI case examples for the probable AIS grade changes in the event of recovery.

**Objectives:** To demonstrate the possible problems with AIS classification in SCI cases involving presumed motor and sensory changes, and to clarify the possible causes of the inverse relationship between the motor/sensory changes and AIS conversion in certain conditions.

**Setting:** Ankara, Turkey.

**Methods:** We studied the case examples of reference from the 2011 revision of International Standards for the Neurological Classification of Spinal Cord Injury.

**Results:** We encountered the same unique problem of deteriorating AIS grades within the critical zones of conversion when presumed neurological improvement took place, and *vice versa*.

**Conclusion:** When recovery occurs without observing any motor or sensory changes while taking only the AIS into account, it would be possible to make an incorrect conclusion. This is most likely an indication of a limitation of the AIS. To enlighten this paradox, the large amount of data in SCI databases should be reanalyzed.

*Spinal Cord* (2014) **52**, 667–670; doi:10.1038/sc.2014.89; published online 3 June 2014

## INTRODUCTION

The American Spinal Injury Association (ASIA) assessments are the most frequently used instruments in spinal cord injury (SCI) clinical trials for measuring neurological damage and recovery.<sup>1,2</sup> The completeness of the SCI is graded by the ASIA impairment scale (AIS) with grades ranging from A to E, and the motor and sensory abilities of the patients are described using the ASIA motor and sensory scores.<sup>1,2</sup> Patients usually exhibit a combination of slight to robust motor and sensory changes at different levels, and these could contribute to or accompany the AIS conversion.<sup>3</sup>

Recovery is determined by conversions in the AIS and/or changes in the ASIA motor and sensory scores,<sup>2</sup> while recovery rates are mostly based on conversion between the AIS grades.<sup>4</sup> To better predict patient outcomes in recovering SCI patients, it is vital to understand whether the change in AIS is due to a change in the neurological level or due to a true neurological recovery. Consequently, the International Standards for the Neurological Classification of Spinal Cord Injury (International Standards for the Neurological Classification of Spinal

Cord Injury (ISNCSCI)), which were revised in 2011, were developed to have accurate communication between researchers.<sup>5,6</sup>

## MATERIALS AND METHODS

In our clinical training program, which includes probable AIS grade changes in the event of recovery, we have noticed some confounding results regarding the AIS grading in SCI patient case examples who are expected to recover. Some cases showed worsening of AIS classification despite having actually neurological improvement in the event of presumed recovery, and *vice versa*. Subsequently, we performed a computerized literature search of PubMed from 1980 to December 2013. The keywords: 'spinal cord injury', 'recovery', 'ASIA impairment scale', 'International standards for the neurological classification of spinal cord injury' and the MeSH terms 'spinal cord injuries', 'recovery of function', 'outcome scale', 'classification' were used. We found one study by Spiess *et al.*<sup>3</sup> that has reported a conflict between AIS grade conversion and neurological changes in European Multicenter Study on Human Spinal Cord Injury study. Therefore, we decided to show the limitation of AIS and to clarify the possible causes of inverse relationship between the motor/sensory changes and AIS conversion in certain conditions by using the case examples of

<sup>1</sup>Department of Physical Therapy and Rehabilitation, Ministry of Health Ankara Diskapi Yildirim Beyazit Education and Research Hospital, Ankara, Turkey and <sup>2</sup>Ministry of Health Ankara Physical Therapy and Rehabilitation Hospital, Ankara, Turkey

Correspondence: Dr İ Gündoğdu, Department of Physical Therapy and Rehabilitation, Ministry of Health Ankara Diskapi Yildirim Beyazit Education and Research Hospital, İrfan Baştuğ Cd. Dışkapı, Ankara 06450, Turkey.

E-mail: ibrahimftr@gmail.com

Received 17 February 2014; revised 15 April 2014; accepted 1 May 2014; published online 3 June 2014

**Table 1 Case example differentiating AIS C from D**

	Motor scores		Light touch		Pinprick		
	Right	Left	Right	Left	Right	Left	
<i>Initial assessment</i>							
			C2	2	2	2	2
			C3	2	2	2	2
			C4	2	2	2	2
C5	5	5	C5	2	2	2	2
C6	5	5	C6	2	2	2	2
C7	5	5	C7	2	1	2	0
C8	5	3	C8	1	1	1	0
T1	2	0	T1	2	2	2	2
			T2	1	2	2	2
Total	22	18	T3	1	2	2	0
			T4	2	2	0	0
Neurological level			T5	2	2	0	0
			T6	2	2	0	0
Motor	C8	C8	T7	2	1	0	0
Sensory	C7	C6	T8	1	2	0	0
Single NLI		C6					
V.A.C: Yes			T9	2	2	0	0
AIS grade: D			T10	2	2	0	0
			T11	1	2	1	1
			T12	2	1	0	1
L2	4	1	L1	1	1	0	0
L3	5	1	L2	1	1	0	1
L4	5	0	L3	1	1	0	1
L5	5	0	L4	1	1	0	0
S1	2	0	L5	1	1	0	1
Total	21	2	S1	1	1	0	1
Upper limb total: 40			S2	2	2	0	2
Lower limb total: 23			S3	1	1	0	1
			S4/5	1	1	0	1
			Total	43	44	20	24
<i>Second assessment</i>							
			C2	2	2	2	2
			C3	2	2	2	2
			C4	2	2	2	2
C5	5	5	C5	2	2	2	2
C6	5	5	C6	2	2	2	2
C7	5	5	C7	2	2	2	2
C8	5	3	C8	1	1	1	0
T1	2	0	T1	2	2	2	2
			T2	1	2	2	2
Total	22	18	T3	1	2	2	0
			T4	2	2	0	0
Neurological level			T5	2	2	0	0
			T6	2	2	0	0
Motor	C8	C8	T7	2	1	0	0
Sensory	C7	C7	T8	1	2	0	0
Single NLI:		C7					
V.A.C: Yes			T9	2	2	0	0
AIS grade: C			T10	2	2	0	0
			T11	1	2	1	1
			T12	2	1	0	1
L2	4	1	L1	1	1	0	0
L3	5	1	L2	1	1	0	1
L4	5	0	L3	1	1	0	1
L5	5	0	L4	1	1	0	0
			L5	1	1	0	1

**Table 1 (Continued)**

	Motor scores		Light touch		Pinprick		
	Right	Left	Right	Left	Right	Left	
S1	2	0	S1	1	1	0	1
Total	21	2	S2	2	2	0	2
Upper limb total: 40			S3	1	1	0	1
Lower limb total: 23			S4/5	1	1	0	1
			Total	43	45	20	26

Abbreviations: AIS, ASIA impairment scale; NLI, neurologic level of injury; VAC, voluntary anal contraction.

*Initial assessment:* Right sensory level: C7, left sensory level: C6, bilateral motor level: C8 and single NLI: C6, VAC: Yes. Below single NLI: 8/16 testable muscle grade  $\geq 3 = AIS D$ .

*Second assessment: Sensorial improvement at C7:* right sensory level: C7, left sensory level: C7, bilateral motor level: C8 and single NLI: C7, VAC: Yes. Below single NLI: 6/14 testable muscle grade  $\geq 3 = AIS C$ .

If we took the initial assessment point as a starting point, sensorial improvement at C7 level would cause deterioration from AIS D to C.

If we took second assessment point as a starting point, sensorial deterioration at C7 level would cause an improvement from AIS C to D. (Case example is adapted from 'Reference for the 2011 revision of the International Standards for Neurological Classification of Spinal Cord Injury. *J Spinal Cord Med* 2011; 34: 547-554'.)

reference for the 2011 revision of ISNCSCI,<sup>6</sup> as it was developed to have accurate communication between researchers.

The International Standards examination were used to distinguish between a sensory incomplete and a motor incomplete (AIS B from C) injury, and between motor incomplete injuries (AIS C from D). The following definitions from the 2011 revision of ISNCSCI<sup>5</sup> have been used to describe the unique problem of deteriorating AIS grades when presumed neurological improvement took place:

- (1) *Sensory level:* The sensory level is the most caudal, intact dermatome for both pinprick and light touch sensation.
- (2) *Motor level:* The motor level is determined by examining the key muscle functions within each of 10 myotomes and is defined by the lowest key muscle function that has a grade of at least 3 (on supine manual muscle testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5).
- (3) *Neurological level of injury (NLI):* The NLI refers to the most caudal segment of the cord with intact sensation and antigravity muscle function strength, provided that there is normal (intact) sensory and motor function rostrally.
- (4) *Distinguishing between a sensory incomplete versus a motor incomplete (AIS B from C) injury:* The motor level on each side is used to differentiate AIS B from C injuries.
- (5) *Distinguishing between motor incomplete injuries (AIS C from D):* The single neurological level (based on the proportion of key muscle functions with strength grade 3 or greater) is used to differentiate AIS C from D injuries.

**RESULTS**

**The analysis of SCI case example used in the reference article that differentiated AIS C from AIS D for the probable AIS grade changes in the event of recovery**

The sensory level was C7 on the right and C6 on the left. In addition, the bilateral motor level was C8 and the single NLI was C6 with the presence of voluntary anal contraction. Additionally, 8 out of 16 testable key muscle functions received a grade of  $\geq 3$  below the single NLI, resulting in the AIS D classification. In that example, if the case involved an acute injury and the patient only recovered normal sensory function at the C7 level on the left side, this would change the single NLI to C7, which would exclude the two key muscles that received a grade of  $\geq 3$  at C7. That would leave only 6 of the 14 testable key muscle functions below the single NLI grade of  $\geq 3$ ,

**Table 2 Case example differentiating AIS B from C**

		Motor scores		Light touch		Pinprick	
		Right	Left	Right	Left	Right	Left
<i>Initial assessment</i>							
			C2	2	2	2	2
			C3	2	2	2	2
			C4	2	2	2	2
C5	5	5	C5	2	2	2	2
C6	4	3	C6	1	1	1	1
C7	3	1	C7	0	0	0	0
C8	1	0	C8	0	0	0	0
T1	1	0	T1	0	0	0	0
			T2	0	0	0	0
Total	14	9	T3	0	0	0	0
			T4	0	0	0	0
Neurological level			T5	0	0	0	0
			T6	0	0	0	0
Motor	C6	C6	T7	0	0	0	0
Sensory	C5	C5	T8	0	0	0	0
V.A.C: No			T9	0	0	0	0
AIS grade: B			T10	0	0	0	0
			T11	0	0	0	0
			T12	0	0	0	0
L2	0	0	L1	0	0	0	0
L3	0	0	L2	0	0	0	0
L4	0	0	L3	0	0	0	0
L5	0	0	L4	0	0	0	0
S1	0	0	L5	0	0	0	0
Total	0	0	S1	0	0	0	0
Upper limb total: 23			S2	0	0	0	0
Lower limb total: 0			S3	0	0	0	0
			S4/5	0	0	0	1
			Total	9	9	9	10
<i>Second assessment</i>							
			C2	2	2	2	2
			C3	2	2	2	2
			C4	2	2	2	2
C5	5	5	C5	2	2	2	2
C6	2	3	C6	1	1	1	1
C7	3	1	C7	0	0	0	0
C8	1	0	C8	0	0	0	0
T1	1	0	T1	0	0	0	0
			T2	0	0	0	0
Total	12	9	T3	0	0	0	0
			T4	0	0	0	0
Neurological level			T5	0	0	0	0
			T6	0	0	0	0
Motor	C5	C6	T7	0	0	0	0
Sensory	C5	C5	T8	0	0	0	0
V.A.C: No			T9	0	0	0	0
AIS grade: C			T10	0	0	0	0
			T11	0	0	0	0
			T12	0	0	0	0
L2	0	0	L1	0	0	0	0
L3	0	0	L2	0	0	0	0
L4	0	0	L3	0	0	0	0
L5	0	0	L4	0	0	0	0
S1	0	0	L5	0	0	0	0
Total	0	0	S1	0	0	0	0
			S2	0	0	0	0

**Table 2 (Continued)**

		Motor scores		Light touch		Pinprick	
		Right	Left	Right	Left	Right	Left
Upper limb total: 21			S3	0	0	0	0
Lower limb total: 0			S4/5	0	0	0	1
			Total	9	9	9	10

Abbreviations: AIS, ASIA impairment scale; VAC, voluntary anal contraction.  
*Initial assessment:* Right motor level: C6, left motor level: C6, sensory sacral sparing: Yes, VAC: No. There is *no sparing* more than three levels below C6 motor level = AIS B.  
*Second assessment:* Motor deterioration at C6 on the right side (from grade 4 to 2); right motor level: C5, left motor level C6, sensory sacral sparing: Yes, VAC: No. There is a *sparing* more than three levels below C5 motor level on the right side = AIS C.  
 If we took the initial assessment point as a starting point, motor *deterioration* at C6 level would cause an *improvement* from AIS B to C.  
 If we took second assessment point as a starting point, motor *improvement* at C6 level (from grade 2 to at least 3) would cause a *deterioration* from AIS C to B. (Case example is adapted from 'Reference for the 2011 revision of the International Standards for Neurological Classification of Spinal Cord Injury. *J Spinal Cord Med* 2011; 34: 547-554'.)

meaning that this patient would ultimately be reclassified as an AIS C. In other words, worsening in classification status would occur despite a small degree of sensorial improvement. If we replicate cases with sensory levels above the motor level, then in patients with a slight improvement in sensory function, a common occurrence after spinal cord injuries at an early phase, a resulting change in the single NLI level would occur along with the exclusion of key muscles with a grade of  $\geq 3$ . Moreover, these muscles are always tested before any improvement in sensory function, which would result in a lower AIS grade. As the sensory or motor function may worsen in some cases in the early stages<sup>3</sup> and changes in total sensory and motor scores could be in the same or opposite directions,<sup>7</sup> we also considered the same example in reverse because a change in sensorial deterioration without a corresponding motor function change would lead to an improvement in the AIS grade (Table 1).

**The analysis of SCI case example used in the reference article that differentiated AIS B from AIS C for the probable AIS grade changes in the event of recovery**

When we try to distinguish between AIS B and AIS C, changes in sensory levels do not cause any problems as it is only possible to convert AIS B to AIS C if there is motor sparing more than three levels below the motor level on either side of the body in a patient with sensory sacral sparing along with no appearance of voluntary anal contraction. However, the case example in the reference article differentiated between AIS B and AIS C, indicating that the patient had a bilateral sensory level of C5, a bilateral motor level of C6, sensory sacral sparing without voluntary anal contraction and the following motor grades on the right side: C5 = 5, C6 = 4, C7 = 3, C8 = 1 and T1 = 1. If the deterioration at the C6 (a decrease in muscle strength from 4 to 2) is taken into account, this would immediately change the motor level from C6 to C5 on the right side. Since there was sparing more than three levels below this motor level (T1 muscle strength grade of 1), furthermore, the classification would improve from AIS B to AIS C in spite of the deterioration in motor function. If the same example is again reversed, the improvement in motor function from C5 to C6 would cause a corresponding deterioration in the AIS grade from C to B (Table 2).

**Main findings**

- (1) When distinguishing between motor incomplete injuries (AIS C from D) in SCI cases with sensory levels above the motor level, in

the event of a slight improvement in sensory function, a resulting change in the single NLI level would occur along with the exclusion of key muscles with a grade of  $\geq 3$ , which would result in a lower AIS grade; in other words, worsening in classification status would occur despite a small degree of sensorial improvement. In reverse, a sensorial deterioration without a corresponding motor function change, in which the sensory levels are below or at the same motor level, would lead to an improvement in the AIS grade as well. These inverse relationships are the examples of the problem concerning primarily the 5th ASIA definition mentioned in the method section.

- (2) When distinguishing between a sensory incomplete versus a motor incomplete (AIS B from C) injury in SCI cases with sparing more than three levels below the motor level on either side of body (AIS C) without voluntary anal contraction, the motor improvement on corresponding side, a resulting change in the motor level would occur along with exclusion of sparing more than three levels below the motor level, which would result in the classification a deterioration from AIS C to AIS B in spite of the improvement in motor function. In reverse, motor deterioration, in which there is no sparing more than three levels below the motor level (AIS B), would cause a corresponding improvement in the AIS grade from B to C as well. These inverse relationships are the examples of the problem concerning primarily the 4th ASIA definition mentioned in the method section.
- (3) All four AIS conversions described above might be in the 'critical zone of conversion' as they resulted from changes in a single motor or sensory level, and may reflect a problem concerning the ASIA definition rather than a true neurological recovery or deterioration.

## DISCUSSION

Although the AIS is regularly used to classify the severity of the initial SCI, the conversion rate of the AIS has also frequently been used as a measurement of neurological outcomes in clinical trials. The limitations of using the AIS as an instrument to measure outcomes have been discussed in previous studies and more recent studies have tended to use the AIS grade conversion and motor scores simultaneously, or they have proposed that detecting sensory and motor changes may require more sensitivity than measuring AIS grade conversion, especially when attempting to calculate therapeutic efficacy.<sup>8,9</sup>

Many studies in the literature have focused on AIS conversion in SCI patients, but, to the best of our knowledge, only the study by Spiess *et al.*<sup>3</sup> reported a conflict between AIS grade conversion and neurological changes. They reported only 1 out of a total of 90 patients, based on the data from the European Multicenter Study on Human Spinal Cord Injury, was converted from AIS B to AIS D owing to a change in motor level arising from sensorial deterioration without a gain in muscle score. However, the inverse relationship between the motor/sensory changes and AIS conversion was not the primary focus of their study. They also speculated that this paradox maybe reflect a problem concerning the ASIA definition or the assessor's level of expertise.

After examining the case examples in the ISNCSI reference article, when recovery occurs without observing any motor or sensory changes while taking only the AIS conversion into account, we believe that it would be possible to make an incorrect conclusion. Furthermore, this is most likely another indication of a limitation of the AIS.

In a clinical setting, when reporting a patient's progress, it would also be problematic to express, for example, that a patient's sensory/motor scores have improved but that the AIS had gone backward, or *vice versa*. For this reason, these findings may guide clinicians regarding prognosis and treatment decisions, including the consideration of critical conversion zones as a discrepancy factor when grading AIS. In our opinion, 'the ASIA Standards' is a result of an extensive and evolving work from experts in SCI research. The ASIA Standards has been revised several times in the past and currently it still is the best SCI classifications system we have. Other widely accepted SCI measurement tools, such as the Modified Benzel classification, might also be prone to such problems. None of them could provide a global measure of all cord functions. It would be very difficult to classify and assess such a complex continuum that evolves over time, in a comprehensible classification system that provides researchers the opportunity to coordinate properly.

## CONCLUSION

Results of this analysis confirm that the AIS classification can yield clinically illogical results, regarding the neurological level change contributing AIS grade changes that occur within the critical conversion zones. When recovery occurs without observing any motor or sensory changes while taking only the AIS conversion into account, we believe that it would be possible to make an incorrect conclusion. Furthermore, this is most likely another indication of a limitation of the AIS. In addition, we also believe that the large amount of SCI data in databases such as the Sygen and European Multicenter Study on Human Spinal Cord Injury should be reanalyzed, as a significant amount of the reported cases of AIS deterioration have originated from them.

## DATA ARCHIVING

There were no data to deposit.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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