CHAPTER 4

Clinical Manifestations of Acute Spinal Cord Injury

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The effective management of patients with acute spinal cord injury (SCI) depends upon accurate clinical examination and classification of the neurological injury and detailed radiological assessment of the vertebral column injury.[15] The most useful clinical classification is based on the assessment of the functional neurological damage as determined by the clinical examination rather than on other criteria such as the pathological, electrophysiological, or imaging features. Accurate clinical and radiological assessments permit the development of a rational treatment plan and the determination of the likely prognosis. The neurological assessment and classification must be sufficiently reliable to allow accurate comparisons of serial observations by the same or different observers. In the early 1990s, the American Spinal Injury Association (ASIA) convened consensus meetings of representatives from several disciplines involved in the management of patients with acute SCI and from several countries, and in 1992, ASIA along with the International Medical Society of Paraplegia (IMSOP) published the *International Standards for Neurological and Functional Classification of Spinal Cord Injury*.[1] This new ASIA/IMSOP classification is a considerable improvement and should be used by all physicians and surgeons who manage patients with acute SCI, just as the Glasgow Coma Scale is used to assess head injuries.

The Initial Clinic Examination

Table 1 shows the "safe assumptions" to make when initially encountering a trauma victim in order to avoid missing the diagnosis or worsening the injury. Since head and spinal injuries can occur together, assume that an unconscious patient also has a spinal injury. To avoid your attention being diverted to the chest or abdomen, assume that, in every case, the multiple-trauma victim has a spinal injury. Since most spinal

TABLE 1

"Safe Assumptions"—
to Aid in the Diagnosis of SCI

- Every patient with a head injury and every unconscious patient has an SCI.
- Every patient with multiple trauma has an SCI.
- Every motor-vehicle accident victim has an SCI.
- Every victim of a sports or recreational accident has an SCI.
- Every severely injured worker has an SCI.
- Every victim of a fall at home has an SCI.
- Every SCI has an unstable spinal column and any movement of the spinal column after trauma will cause further damage to the spinal cord.

injuries result from traffic accidents, work accidents, sports and recreational activities, or from falls at home, assume an SCI in every victim of these accidents. When the spinal cord is injured, always assume that the spinal column is unstable and that any movement can worsen the neurological deficit.

The diagnosis of SCI may be missed because of an inadequate or incomplete history or physical examination or because multiple factors may obscure the diagnosis. For example, inebriated victims of a car accident who were not wearing a seatbelt may have sustained a head injury as well as an SCI. The combination of the head injury and inebriation make it extremely difficult to examine the patient. Also, the presence of multiple trauma may divert the examiner's attention toward more obvious, but often less important, injuries such as limb fractures. Other difficult situations include patients who are psychologically upset by the injury or who are hypoxic and become restless, uncooperative, or agitated. In all of these instances, the practitioner's diagnostic acumen is severely taxed. Indeed, the patient's reactions may be so bizarre that the diagnosis of hysteria may be mistakenly made. This diagnosis is extremely dangerous in situations involving trauma. Thus, in the presence of alcohol, multiple trauma, head injury, or bizarre behavior, one must make the "safe assumption" that there is an accompanying SCI. With major trauma to the abdomen or chest, one should always suspect that the trauma might have been sufficient to dislocate the spine.

The history provided by the accident victim, a witness, or the ambulance personnel may provide important clues that lead to the diagnosis of the presence and severity of an SCI. At the accident scene, was there leg movement only to have this function disappear later, or were the limbs motionless with subsequent gradual improvement? The former situation would indicate an unstable spine with severe pressure on the cord from progressive dislocation, whereas the latter may indicate a period of spinal shock that is now passing. Symptoms such as the inability to move one or more limbs or a relative lack of movement of one or more limbs are highly suspicious. Complaints of weakness, tingling, or loss of sensation are extremely important. Similarly, post-traumatic urinary retention and incontinence are danger signs.

The physical examination can yield specific indications of the presence of an SCI. These "spinal clues" are obtained from a detailed testing of the vital signs as well as strength, sensation, and reflexes in all four limbs (Table 2). The spine must be palpated in its entirety, paying special attention to tenderness, swelling, step-deformity, or crepitus. It is important to realize that the examiner's hand can be passed safely between the patient and the mattress or stretcher, and the spine palpated from the foramen magnum to the sacrum. This must be done in every instance.

Hypotension, bradycardia, and warm extremities are due to a cervical SCI and not to systemic shock, which usually causes hypotension, tachycardia, and cold extremities. It should be recognized that a cervical injury causes paradoxical respiration in which inspiration causes the chest cage to be drawn in while the abdomen expands due to intercostal muscle paralysis and preserved diaphragmatic contraction. Also, do not misinterpret reflex withdrawal of the limbs in response to "painful" stimulation of the extremities as being due to voluntary movement.

ASIA/IMSOP Impairment Scale

Table 3 shows the ASIA/IMSOP impairment scale containing five grades of impairment:

TABLE 2

"Spinal Clues" — to Aid in the Diagnosis of SCI (Especially Useful in Impaired Consciousness or Cooperation)

- Hypotension and bradycardia occur in spinal shock
- Paradoxical respiration
- Low body temperature and high skin temperature
- Priapism
- Bilateral paralysis of arms and legs, especially flaccid
- Bilateral paralysis of either arms only or arms more than legs, especially flaccid
- Bilateral paralysis of legs, especially flaccid
- Lack of response to painful stimuli
- Detection of an anatomic level in response to painful stimuli
- Painful stimulation produces only head movement or facial grimacing
- Sweating level
- Horner's syndrome
- Brown-Séquard syndrome

Grade A denotes a complete injury, Grades B, C, and D denote varying levels of incomplete injury, and Grade E denotes a patient with normal motor and sensory spinal cord function. A complete injury (Grade A) is now defined as absence of sensory and motor function in the lowest sacral segment, as originally described by Waters et al.[27] A Grade B patient has sensory preservation only below the level of injury. Grades C and D were originally described by Frankel et al[8] as preserved motor function being "useless" in Grade C and "useful" in Grade D. The new scale defines the function more precisely on the basis of the Medical Research Council muscle grading system:[14] in Grade C the majority of key muscles below the neurological level have a muscle grade of lower than 3, and in Grade D the majority of key muscles below the neurological level have a muscle grade of 3 or greater. The latter modifications are based on the classification of Tator et al.[25]

The new ASIA/IMSOP grading scale improves the ability to distinguish precisely between complete and incomplete injuries. To make this distinction, the clinician must test

TABLE 3

ASIA and IMSOP ASIA/IMSOP Impairment Scale: Spinal Cord Injury Based on the International Standards for Neurological and Functional Classification

Grade A	Complete injury	No motor or sensory function is preserved in the sacral segments S4–5.
Grade B	Incomplete injury	Sensory but not motor function is preserved below the neurological level and extends through the sacral segments S4–5.
Grade C	Incomplete injury	Motor function is preserved below the neurological level, and the majority of key muscles below the neurological level have a muscle grade less than 3.
Grade D	Incomplete injury	Motor function is preserved below the neurological level, and the majority of key muscles below the neurological level have a muscle grade 3 or greater.
Grade E	Normal	Motor and sensory function are normal.

both touch and pin prick sensation in the lowest sacral dermatomes perianally at the mucocutaneous junction, as well as deep anal sensation. Also, voluntary motor contraction of the external anal sphincter must be tested by digital examination. The distinction between complete and incomplete injury is crucial in order to plan treatment and to predict outcome.

As noted in Chapter 3, the prognosis for neurological recovery is vastly better in incomplete than in complete injuries at all levels of the spinal cord.[23] However, even complete cord injuries have some potential for recovery. Most large series of acute SCI patients have shown a small percentage of initially complete cases (usually 1% to 2%) with significant recovery of distal cord function.[9] It could be argued that patients who recover from a complete injury represent a misdiagnosis due to the difficulties described above, including inebriation, sedative or other drug effects, spinal shock, uncooperativeness, or a concomitant head injury. The author believes that approximately 1% to 2% of patients with complete SCI recover significant distal cord function, even in the absence of all factors that can interfere with precise, early classification, and that early appropriate treatment can increase this number.

Neurological and Vertebral Levels of SCI

The new ASIA/IMSOP classification provides precise definitions for the neurological, sensory, and skeletal levels, as well as zone of partial preservation (Figure 1). The neurological level is the most caudal segment of the spinal cord with normal sensory and motor function on both sides of the body. Because normal segments may differ on the two sides and may differ in terms of motor and sensory function, there may be up to four different segments identified in determining the neurological level (i.e., right sensory, left sensory, right motor, and left motor). These levels are determined by neurological examination of a key sensory point in each of 28 right and 28 left dermatomes and a key muscle in each of 10 right and 10 left myotomes. A zone of partial preservation may be present in complete injuries and is defined as encompassing those dermatomes and myotomes caudal to the neurological level that remain partially innervated (Table 4).

The vertebral level of an injury is defined as the level of greatest vertebral damage on radiological examination. It is clear that the vertebral level and the neurological levels may be similar or may differ by one or more segments.

Recently, there has been an emphasis on determining the effect of SCI on the overall function of the patient. To date, a specific functional measure has not been developed for SCI, but there is evidence that the functional independence measurement (FIM) developed for other neurological disorders[10] is useful for SCI patients as well. For example, in the recently completed third National Acute Spinal Cord Injury study of methylprednisolone versus tirilazad, the FIM result was one of the outcome measures of this clinical trial.[6]

Spinal Shock

Spinal shock is a type of neurogenic shock that occurs in major SCI and can be a source of considerable confusion. Systemic shock, such as a thoracic cord injury with a concomitant aortic injury, also can occur in SCI patients. Spinal shock implies the loss of somatic motor, sensory, and sympathetic autonomic function due to SCI.[12] The more severe the SCI and the higher the level of injury, the greater the severity and duration of spinal shock. Thus, spinal shock is most severe in complete upper cervical cord injuries, less severe in incomplete thoracic injuries, and minimal in lumbar cord injuries.

The somatic motor component of spinal shock consists of paralysis, flaccidity, and areflexia with respect to deep tendon reflexes and cutaneous reflexes, and the sensory component is anesthesia to all modalities. The autonomic component is systemic hypotension, skin hyperemia and warmth, and bradycardia due to loss of sympathetic function but persisting parasympathetic function (unopposed vagotonia). The exact mechanism of spinal shock is unknown but may be due to temporary local effects on impulse conduction in the traumatized spinal cord caused by electrolyte or neurotransmitter changes.

In the first few hours and days after an SCI,

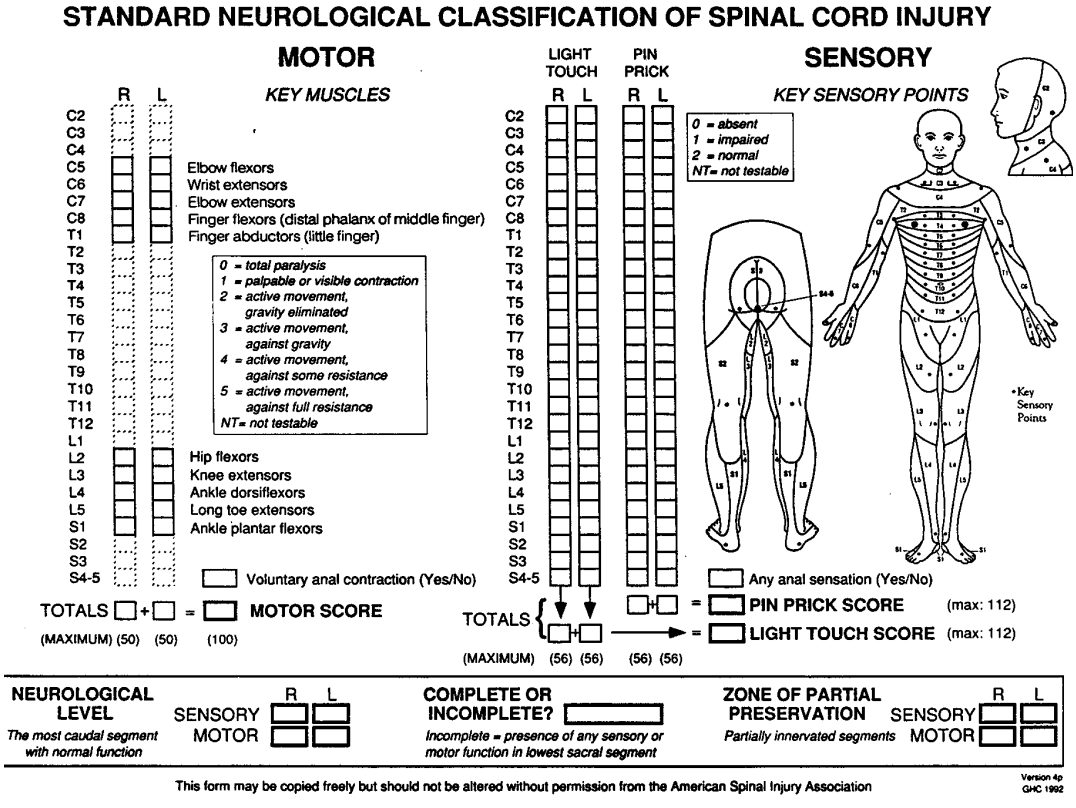

Figure 1: Neurological classification of SCI (ASIA/IMSOP). This diagram contains the principal information about motor, sensory, and sphincter function necessary for accurate classification and scoring of acute SCI. The 10 key muscles to be tested for the motor examination are shown on the left along with the Medical Research Council grading system, and the 28 dermatomes to be tested on each side for the sensory examination are shown on the right. The system for recording the neurological level(s), the completeness of the injury, and the zone of partial preservation (in complete injuries) are shown at the bottom.

there is often a combination of the temporary physiological effects of spinal shock and the more permanent pathological effects of the cord injury. Another problem is the variable duration of spinal shock. The author recommends the following guidelines: 1) the somatic motor and sensory components of spinal shock last only 1 hour or less, and thus have terminated by the time the majority of patients are examined in the initial hospital admission, which in most countries is within 1 to 4 hours of injury; and 2) the reflex and autonomic components of spinal shock may last from days to months, depending on the level and severity of cord injury. In practical terms, these guidelines mean that the motor and sensory deficits detected 1 hour or more after SCI are due to physical SCI rather than to spinal shock. This is certainly a safe course to follow because it eliminates the possible error of missing a serious SCI because the observed deficits were presumed due to spinal shock.

Incomplete Acute SCI Syndromes

There are many types of incomplete acute neurological syndromes occurring in an SCI (Table 4). These syndromes are generally named according to the presumed location of the injury in the transverse plane of the spinal cord (Figures 2 to 8).[24] In addition to grading patients according to the ASIA/IMSOP scale, it is helpful for practitioners to categorize the incomplete

TABLE 4

ACUTE SPINAL CORD INJURY SYNDROMES IN TRAUMA PATIENTS

Complete spinal cord injury
ASIA/IMSOP Grade A
Unilevel: no zone of partial preservation
Multiple level: zone of partial preservation
Incomplete spinal cord injury
ASIA/IMSOP Grades B, C, and D
Cervicomedullary syndrome
Central cord syndrome
Anterior cord syndrome
Posterior cord syndrome
Brown-Séquard syndrome
Conus medullaris syndrome
Complete cauda equina injury
ASIA/IMSOP Grade A
Incomplete cauda equina injury
ASIA/IMSOP Grades B, C, and D
Reversible or transient syndromes
Cord concussion
Burning hands syndrome
Contusio cervicalis
Hysteria

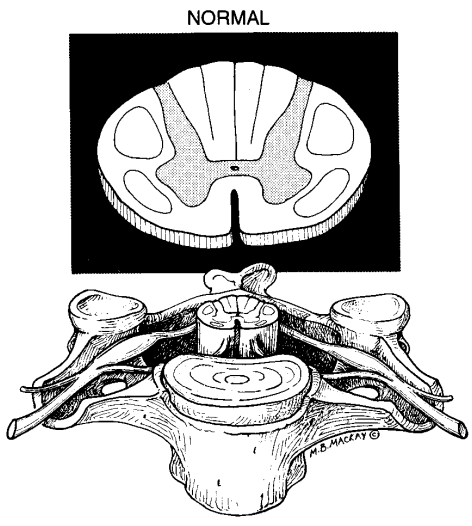

Figure 2: The normal spinal cord and spinal column. The normal relationships between the spinal cord, spinal column, and nerve roots are depicted in the mid-cervical region. The dura has been omitted for clarity. In the upper diagram, the gray matter is finely stippled, and the corticospinal and spinothalamic tracts are outlined. The intervertebral disc is shown. Reprinted with permission from Tator.[23]

patients according to the location of the injury in the spinal cord. First, recognition of the type of incomplete syndrome provides some information about the mechanism of injury, which in turn provides useful information for the selection of treatment. Second, the various categories of incomplete injury have differing prognoses for recovery.

Cervicomedullary Syndrome

A high proportion of injuries to the upper cervical cord will include damage to the medulla as well. These injuries may extend down to C4 or even lower and may extend up to the pons, due either to direct or vascular injury to the vertebral arteries. "Cervicomedullary syndrome" is a useful term to describe the syndromes that involve the upper cervical cord and brainstem, although several other terms have been used, including cruciate paralysis.

The essential features of these include respiratory insufficiency or arrest, hypotension, varying degrees of tetraparesis and hyperesthesia from C1-4, and sensory loss over the face conforming to the onion skin or Déjerine pattern.[19,21] Of course, the higher the lesion, the more severe the manifestations such as those present in patients with atlanto-occipital dislocation. The mechanisms of SCI also include traction injury from severe dislocation as in atlantoaxial dislocation, anterior-posterior compression from burst fracture or odontoid fracture, or ruptured disc. More-prompt and better first-aid account for an increased incidence of these injuries compared with previous experience, due to the larger number of survivors arriving at neurosurgical centers.

It is important to test facial sensation in all patients with cervical SCI, as first urged by Schneider,[19,21] to detect damage to the fibers or cell bodies of the descending spinal tract of the trigeminal nerve or the nucleus of the spinal tract of the trigeminal nerve, respectively, which begin in the pons and medulla and extend downward to at least the C4 cervical segment.