Trauma

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Traumatic spine fractures may result from high-speed injuries which includes motor vehicle collisions, fall from heights and blunt trauma to the head. The cervical spine has a unique anatomic makeup divided into the upper cervical spine and subaxial cervical spine.

Cervical spine injuries remain a significant problem in our present society, over one million acute spine injuries occur in the United States and one third of the spinal cord injuries occur in the cervical spine.

Cervical Spine Anatomy

It is composed of seven vertebrae. The atlas C1 is a ring which articulates with the occiput. It is important to note that the C1 has no body or spinous processes. The axis C2 is so named because it pivots around the atlas turning to rotate the head. The atlas has a vertical extension, the dens, which articulates with C1. There is a canal for the vertebral arteries are located bilaterally.

The upper cervical spine is from occiput to C2 and the subaxial cervical spine is from C3 to C7. Most traumatic cervical spine injury occur in the subaxial region of the cervical spine between C3 and C7.The minority of cervical spine injuries that occur in the upper cervical spine carries with it a high rate of mortality and most people who experience such type of injury expire. Any blunt trauma to the head should raised a high suspicion for at least a cervical spine injury.

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Evaluation

In patients who are suspected to have a cervical spine injury a three view cervical spine X-rays are normally required which includes anteroposterior, lateral and odontoid views, also CT scans have been used more frequently as it provides a better detail of the bony element. MRI is warranted to evaluate the neural elements and the posteroligamentous complex.

A thorough physical examination is of utmost importance documenting all the neurologic findings in detail assessing the motor, sensory and all other reflexes including pathologic reflexes.

There are several types of cervical spine fractures; Jefferson fractures are caused by compression of the base of the skull against C1 resulting in the cracking of the ring of C1. This injury is best identified on the open mouth odontoid x-ray and widening of the lateral masses of C1 away from the dens due to disruption of the C1 ring. Most of these injuries can be treated non surgically in a hard cervical collar.

C2 fractures are usually caused by hyper flexion or hyper extension injuries. They comprise 8% of all the injuries associated with C1 fractures. C2 fractures often present as dens fractures resultant of hyper flexion injuries or Hangman fractures resultant of hyperextension injuries which manifest with bilateral fractures the pedicles of C2. Fractures above C4 can be associated with paralysis of muscles of respiration. The diaphragm is innervated by the C3–C5 nerve roots. Fractures of the mid cervical region are associated with dysfunction of the upper extremities more often than the lower extremities.

Surgical Indications

Mechanical instability, neurologic demise and compression of the neural elements are the main indications for surgical intervention.

There are several classification systems available to classify cervical spine fractures and help with treatment. The goal of the classification system is to aid in identification of injury pattern, communication between physicians including injury mechanism, injury morphology and aid in treatment. One classification system that seems to try and address all these qualities is the cervical spine injury classification severity score (CSISS) which groups the cervical spine segment into columns [1]. The anterior column, posterior column and the right and left pillars. The anterior column consists of the vertebral body the disc and the posterior longitudinal ligaments, the posterior column consists of the lamina, posterior ligamentous complex, and the pillars consists of the lateral masses and pedicle. Each column is graded from 0 to 5, with 0 being nondisplaced and 5 being maximum displacement or worst possible injury. The CSISS causes the surgeon to evaluate all the critical components and columns of the injury. Patients with a score of 7 or greater most likely underwent surgery compared to those with a score below 7.

The Subaxial cervical injury Classifications described by Vaccaro focuses on the subaxial spine (C3–C7) [2]. It consists of three main categories: injury

morphology, discoligamentous status and neurologic status. Morphology is grouped into for subtypes: compression, which is assigned a numerical value of 1, burst fracture (2), Distraction injury (3), and Rotational injury (4). For the discoligamentous complex (DLC) there are three subcategories: Intact (0), Indeterminant (1) and disrupted (2) and the neurologic status if there is no neurologic change, we assign a numeric grade of 0, a nerve root injury is assigned 1 complete cord injury 2, incomplete cord injury 3 and continuous cord compression in the setting of a neurologic deficit get an additional 1 point. A total score less than or equal to 3 warrants non operative treatment, Total score of 4 either treatment Non operative versus surgical treatment can be chosen and total numeric score of five or greater warrants surgical intervention.

The goal of surgery is to stabilize the spinal column in the midst of instability and decompress the neural elements in the midst of compression. Timely decompression and stabilization of the spinal column when medically feasible in an unstable cervical spine fracture is highly encouraged. The surgical approaches could be anteriorly or from a posterior approach or a combination depending on the complexity of the injury.

Thoracolumbar Spine Injuries

The thoracolumbar spine lends itself with a unique anatomic make up. We have the rigid thoracic spinal column made up of 12 vertebral segments in a kyphotic orientation and the lumbar spine made up of 5 vertebral segments, mobile and lordotic. Most thoracolumbar fractures occur from fall from heights and high energy trauma situations including motor vehicle collisions for the younger patients and all from standing for the older patients most likely due to their inherently less optimal bone quality.

Evaluation of patients with suspected thoracolumbar fractures requires detailed neurologic examination which includes motor sensory and reflex functions of the neural axis. Muscle and sensory grading in addition using the ASIA impairment scale to assess neurologic status is paramount [3] (Fig. 25.1). Figure 25.1a, b summarize the American Spinal Injury Association Standard Neurological Classification of Spinal Cord Injury.

Radiographic Evaluation to assess for instability is required to aid with surgical decision making. Anteroposterior and lateral imaging of the segment and also all contiguous segments of the spine is recommended us there are times in which there may be multiple fractures in different segments of the spine. Imaging of the whole spine is recommended in high energy traumas. CT scan and MRIs are also needed to help classify and assess stability. Immediate mechanical stability can be assessed by looking at the injury morphology, integrity of the posteroligamentous complex assesses the long-term stability and neurologic status assesses the neurologic state.

There have been various classifications systems developed to help classify these fractures and aid with treatment. The thoracolumbar injury classification system (TLICS) is more commonly used due to its comparable simplicity and

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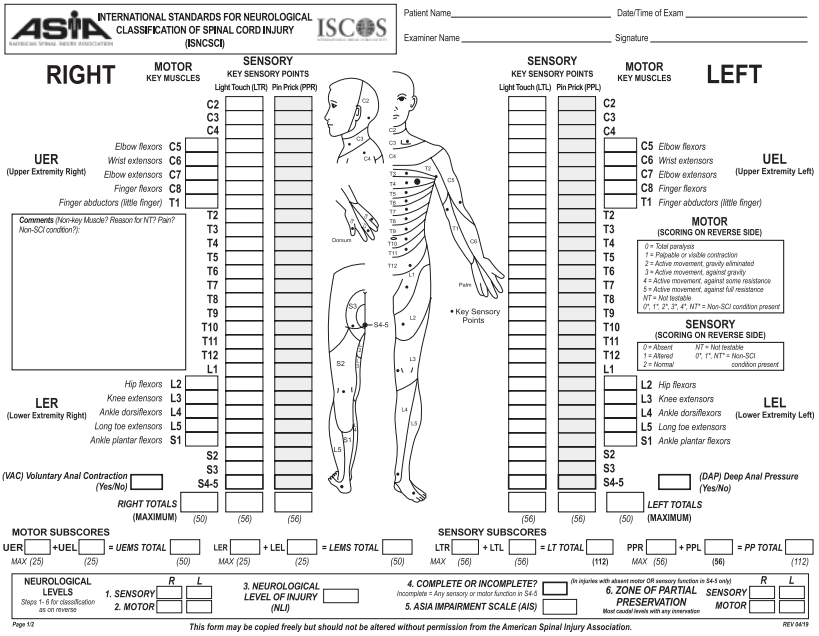

b

Muscle Function Grading

0 = Total paralysis

1 = Palpable or visible contraction

2 = Active movement, full range of motion (ROM) with gravity eliminated

3 = Active movement, full ROM against gravity

4 = Active movement, full ROM against gravity and moderate resistance in a muscle specific position

5 = (Normal) active movement, full ROM against gravity and full resistance in a functional muscle position expected from an otherwise unimpaired person

NT = Not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of > 50% of the normal ROM)

0*, 1*, 2*, 3*, 4*, NT* = Non-SCI condition present [a]

Sensory Grading

0 = Absent **1** = Altered, either decreased/impaired sensation or hypersensitivity

2 = Normal **NT** = Not testable

0*, 1*, NT* = Non-SCI condition present [a]

[a] Note: Abnormal motor and sensory scores should be tagged with a '*' to indicate an impairment due to a non-SCI condition. The non-SCI condition should be explained in the comments box together with information about how the score is rated for classification purposes (at least normal / not normal for classification).

When to Test Non-Key Muscles:

In a patient with an apparent AIS B classification, non-key muscle functions more than 3 levels below the motor level on each side should be tested to most accurately classify the injury (differentiate between AIS B and C).

Movement	Root level
Shoulder: Flexion, extension, adbuction, adduction, internal and external rotation **Elbow:** Supination	C5
Elbow: Pronation **Wrist:** Flexion	C6
Finger: Flexion at proximal joint, extension **Thumb:** Flexion, extension and abduction in plane of thumb	C7
Finger: Flexion at MCP joint **Thumb:** Opposition, adduction and abduction perpendicular to palm	C8
Finger: Abduction of the index finger	T1
Hip: Adduction	L2
Hip: External rotation	L3
Hip: Extension, abduction, internal rotation **Knee:** Flexion **Ankle:** Inversion and eversion **Toe:** MP and IP extension	L4
Hallux and Toe: DIP and PIP flexion and abduction	L5
Hallux: Adduction	S1

ASIA Impairment Scale (AIS)

A = Complete. No sensory or motor function is preserved in the sacral segments S4-5.

B = Sensory Incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5 (light touch or pin prick at S4-5 or deep anal pressure) AND no motor function is preserved more than three levels below the motor level on either side of the body.

C = Motor Incomplete. Motor function is preserved at the most caudal sacral segments for voluntary anal contraction (VAC) OR the patient meets the criteria for sensory incomplete status (sensory function preserved at the most caudal sacral segments S4-5 by LT, PP or DAP), and has some sparing of motor function more than three levels below the ipsilateral motor level on either side of the body. (This includes key or non-key muscle functions to determine motor incomplete status.) For AIS C – less than half of key muscle functions below the single NLI have a muscle grade ≥ 3.

D = Motor Incomplete. Motor incomplete status as defined above, with at least half (half or more) of key muscle functions below the single NLI having a muscle grade ≥ 3.

E = Normal. If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.

Using ND: To document the sensory, motor and NLI levels, the ASIA Impairment Scale grade, and/or the zone of partial preservation (ZPP) when they are unable to be determined based on the examination results.

AMERICAN SPINAL INJURY ASSOCIATION

INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

ISCOS

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Steps in Classification

The following order is recommended for determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.
The sensory level is the most caudal, intact dermatome for both pin prick and light touch sensation.

2. Determine motor levels for right and left sides.
Defined by the lowest key muscle function that has a grade of at least 3 (on supine testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5).
Note: in regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.

3. Determine the neurological level of injury (NLI).
This refers to the most caudal segment of the cord with intact sensation and antigravity (3 or more) muscle function strength, provided that there is normal (intact) sensory and motor function rostrally respectively.
The NLI is the most cephalad of the sensory and motor levels determined in steps 1 and 2.

4. Determine whether the injury is Complete or Incomplete.
(i.e. absence or presence of sacral sparing)
*If voluntary anal contraction = **No** AND all S4-5 sensory scores = **0** AND deep anal pressure = **No**, then injury is **Complete**.*
*Otherwise, injury is **Incomplete**.*

5. Determine ASIA Impairment Scale (AIS) Grade.

Is injury Complete? If YES, AIS=A

NO ↓

Is injury Motor Complete? If YES, AIS=B

NO ↓ (No=voluntary anal contraction OR motor function more than three levels below the motor level on a given side, if the patient has sensory incomplete classification)

Are at least half (half or more) of the key muscles below the neurological level of injury graded 3 or better?

NO ↓ **AIS=C** **YES** ↓ **AIS=D**

If sensation and motor function is normal in all segments, AIS=E
Note: AIS E is used in follow-up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact and the ASIA Impairment Scale does not apply.

6. Determine the zone of partial preservation (ZPP).
The ZPP is used only in injuries with absent motor (no VAC) OR sensory function (no DAP, no LT and no PP sensation) in the lowest sacral segments S4-5, and refers to those dermatomes and myotomes caudal to the sensory and motor levels that remain partially innervated. With sacral sparing of sensory function, the sensory ZPP is not applicable and therefore "NA" is recorded in the block of the worksheet. Accordingly, if VAC is present, the motor ZPP is not applicable and is noted as "NA".

Fig. 25.1 (**a**) American Spinal Injury Association Standard Neurological Classification of Spinal Cord Injury. (**b**) American Spinal Injury Association Standard Neurological Classification of Spinal Cord Injury

reproducibility [4]. The TLICS system looks at three critical aspects of the injury: injury morphology, integrity of posteroligamentous complex and neurologic status of the patient.

Injury morphology is grouped into four main subtypes: 1: Compression fracture, which the fracture involves the anterior column of the vertebral body, burst fracture involves the anterior and middle column of the vertebral body, translational/rotational injury and flexion distraction injury. The compression fracture is assigned a numerical value of 1, burst 2, translational/rotational injury 3 and flexion distraction injury (4) (Fig. 25.2). Figure 25.2 is a classification of the main subtypes of spine fractures.

Integrity of the posteroligamentous complex (PLC) is better visualized with the MRI. An intact PLC is given a numerical value of (1), suspected/indeterminant injury (2), and disrupted PLC (3) (Fig. 25.3). Figure 25.3 is a classification of posterior ligamentous complex injury classification.

The thoracolumbar injury classification and severity score (TLICS) is also used to guide surgical decision making.

With the neurologic status, a patient with no neurologic deficit is assigned a numerical value of zero (0), nerve root injury (2), complete cord injury (2) and an incomplete cord injury and cauda equina injury (3).

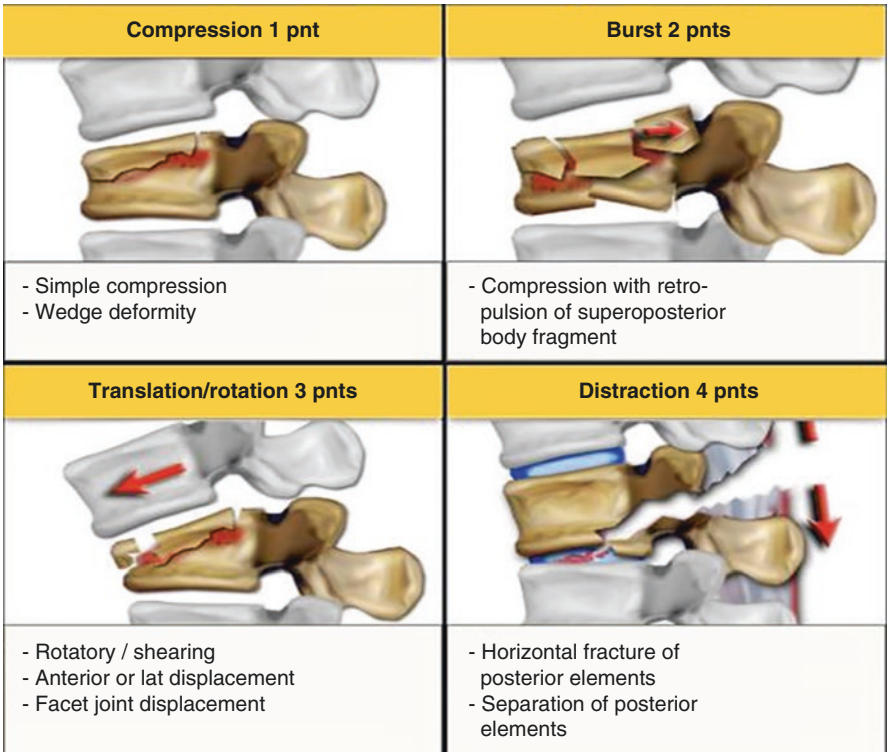

Fig. 25.2 Four main subtypes of spine fractures

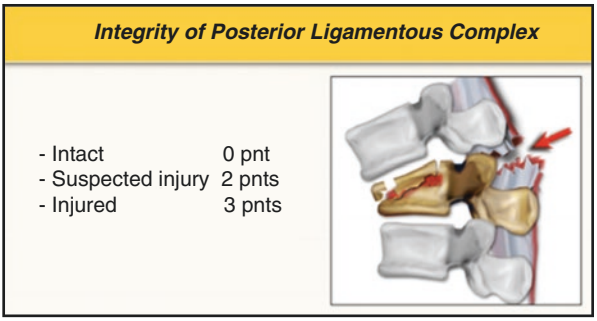

Fig. 25.3 Posterior ligamentous complex injury classification

TLICS 3 independent predictors				
1	**Morphology** immediate stability	- Compression - Burst - Translation/rotation - Distraction	1 2 3 4	- Radiographs - CT
2	**Integrity of PLC** longterm stability	- Intact - Suspected - Injured	0 2 3	- MRI
3	**Neurological status**	- Intact - Nerve root - Complete cord - Incomplete cord - Cauda equina	0 2 2 3 3	- Physical examination
Predicts		**- Need for surgery**	0 – 3 4 > 4	- nonsurgical - surgeon's choice - surgical

Fig. 25.4 Thoracolumbar injury classification and severity score. https://radiologyassistant.nl/musculoskeletal/spine/tlics-classification

Patient with a total score of 3 or less are treated non operatively, A score of 4 patient could be treated non operatively or surgically. A score of 5 or greater warrants surgical intervention. Figure 25.4 is a thoracolumbar injury classification and severity score.

The TLICS system helps in surgical decision making and has been validated by various surgeons due to the scoring system being reliable and reproducible. It takes into consideration all the important segments of the injury and helps the treating physician to consider all the critical aspects of the injury.

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