Lecture 7

Editing File

Acute Spinal Injuries and Cauda Equina Syndrome

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Objectives:

- The ability to demonstrate knowledge of the following:
- Basic anatomy of the spine
- Initial assessment and treatment of spinal injuries at the field
- Principle of spinal stability
- Understanding of neurologic syndromes caused by spinal trauma
- Management of Cauda equina syndrome

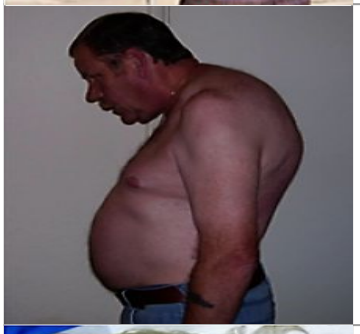
Color Index:

Original text | Doctor's notes | Text book
Important | Golden notes | Extra

Introduction:

Introduction

- We can determine the mechanism of injury from the following pictures.

Examples on Mechanisms of Injury	
	• High velocity injury that is sufficient to cause fracture and traumatic spine injury
	• High power injury if this patient had cervical spinal injury, we must suspect thoracolumbar junction injury because the patient has a hyperextended back with hyperflexed knees (non contiguous level injury), and probably has knee and tibia rotational injuries.
	• Advanced age curved back probably ospteoporotic related injury as well as there is a huge mass in the neck it could be a tumor on top of osteoporosis
	• Fixed cervical flexion and fixed thoracic kyphosis (patient can't raise his head) example of ankylosing spondylitis which is a weak bone due to lack of mobility as well as diffuse spine without buffer mechanism and the shock absorbent mechanism of the disc.
	• Dark spots on the skin it could be a tumor, this could lead to spinal metastasis

Anatomy:

Anatomy of Spine

- The spinal cord appears straight from the coronal view and curved from the sagittal view.

Normal spinal curvatures:

Cervical lordosis, Thoracic kyphosis, Lumbar lordosis and Sacral kyphosis

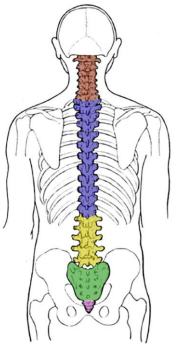
- The spinal column is made up of 33 vertebrae
- The vertebra is made by the fusion of a body and an arch surrounding the spinal cord.

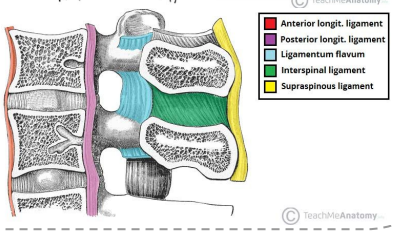
Vertebral Column Functions:

weight bearing and movement

Stabilizing ligaments of the spine:

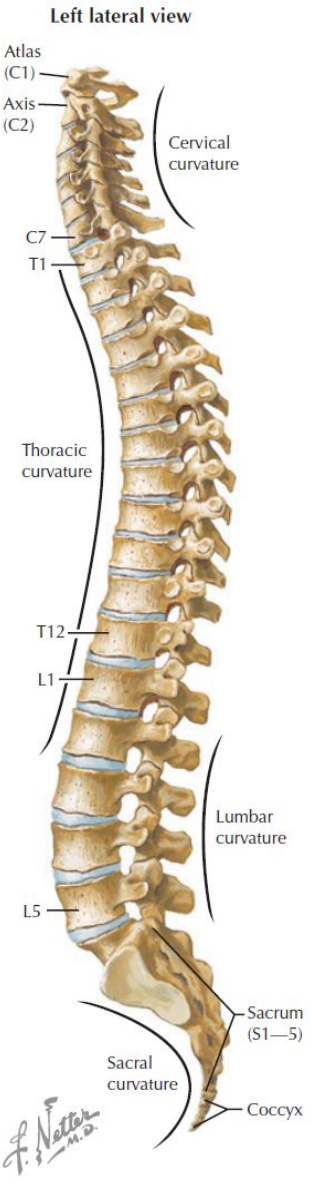
1. Posterior/anterior longitudinal ligament.
2. Apical ligament.
3. Flaccid capsule.
4. Transverse ligament (C1-C2)

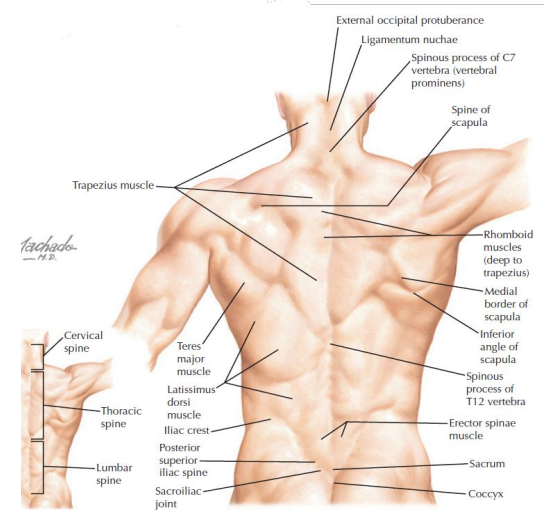


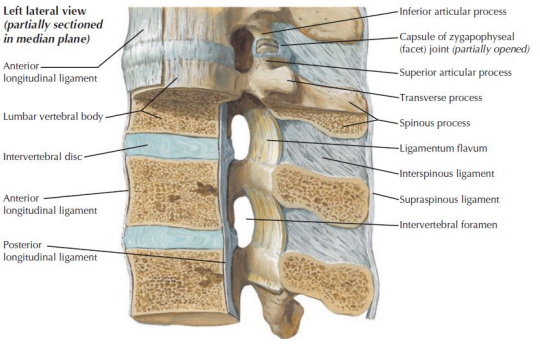


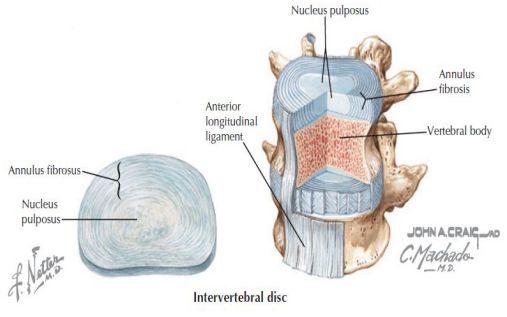
Extra:

GENERAL INFORMATION	
• 33 Vertebrae: 7 cervical, 12 thoracic, 5 lumbar, 5 sacral (fused), 4 coccygeal (fused) • Vertebrae form a functional column • 3 column theory (Denis): spine is divided into 3 columns ◦ Anterior: ALL & anterior ⅔ of vertebral body/annulus ◦ Middle: PLL & posterior ⅓ of vertebral body/annulus ◦ Posterior: Pedicles, lamina, spinous process, and ligaments • Spinal curves: normal curves ◦ Cervical lordosis ◦ Thoracic kyphosis ◦ Lumbar lordosis ◦ Sacral kyphosis	
Spinal Regions	
Cervical	C1-C2: unique bones allow stabilization of occiput to spine and rotation of head. Motion: rotation and flexion/extension.
Thoracic	Relatively stiff due to costal articulations. Motion: rotation. Minimal flexion/extension.
Thoraco-lumbar	Facet orientation transitions from semicoronal to sagittal. Segments are mobile. Most common site of lower spine injuries.
Lumbar	Largest vertebrae. Common site for pain. Houses cauda equina. Motion: flexion/extension. Minimal rotation.
Sacrum	No motion. Is center of pelvis.
Vertebrae	
• Uniquely shaped bones that support the axial musculature and protect the spinal cord and nerve roots	
Body (centrum)	Has articular cartilage on both superior & inferior surfaces. Articulates with intervertebral discs & gets larger distally.
Arch	Made up of pedicles and lamina. Develops from 2 ossifications centers that fuse. Failure to fuse occurs in spina bifida. It forms the vertebral canal for the spinal cord.
Processes	Spinous: ligament attachment site. Transverse: rib (T-spine) and ligament attachment site.
Foramina	Vertebral: spinal cord/cauda equina. Neural: nerve roots exit via here.
LEVEL	**CORRESPONDING STRUCTURE**
C2-3	Mandible
C3	Hyoid cartilage
C4-5	Thyroid cartilage
C6	Cricoid cartilage
C7	Vertebral prominens
T3	Spine of scapula
T7	Xyphoid, tip of scapula
T10	Umbilicus
L1	Conus medullaris (end of cord)
L3	Aorta bifurcation
L4	Iliac crest







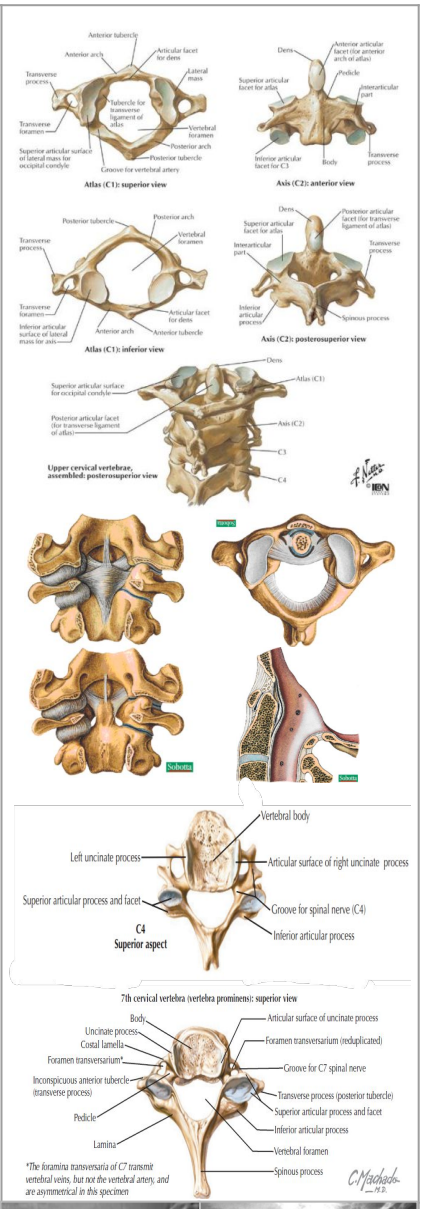


Anatomy:

Cervical Vertebra

Atypical C1 (Atlas) and C2 (Axis)

- The atlas (C1) is only an arch (no body),
- The occipital condyle is a hemisphere that attaches to C1 in the lateral masses.
- C1 on x-ray will only appear as anterior and posterior arches
- The axis (C2) has the odontoid process (dens), (projects upward into the Atlas)
- Between the 2 lateral masses of C1 there is a transverse ligament which fixes the atlas to dense of C2 (Very important stabilizer in atlas arch fractures).
- 50% of flexion/extension (nodding) of the neck is by the atlanto occipital joint.
- 50% of right/left **rotation** of the neck is by the atlantoaxial joint
- So if a patient lost C1 and C2 joints due to fracture or fusion this means he lost 50% of all neck ROM.
- To visualize C1 and C2 on an x-ray we take an open mouth view to see the dens, lateral masses and occipital condyle, (b/c they are obscured by the jaw)
- Lateral masses of C1 (circled above) should be aligned and equal distance from the dens. If not then there might be a fracture in the anterior or posterior arch

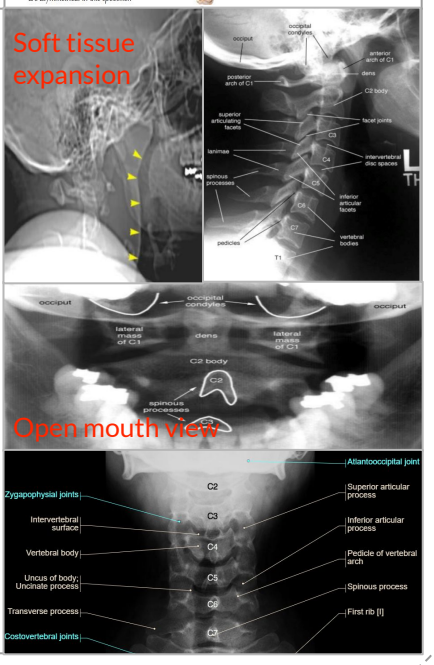


Typical C3-C7

- C3-C7 are more classic vertebrae, having a body, pedicles, laminae, spinous processes, and facet joints.
- Note: all cervical vertebrae (C1 to C7) have a foramen transversarium.
- The vertebral artery travels through foramen transversarium. (only from C1-C6)
- Look for the C spine for any swellings and soft tissue expansion. (top left image)

Normally,

- 7 mm soft tissue shadow in front of C1
- 2-3 mm soft tissue shadow in front of C2
- 22 mm soft tissue shadow in front of C7

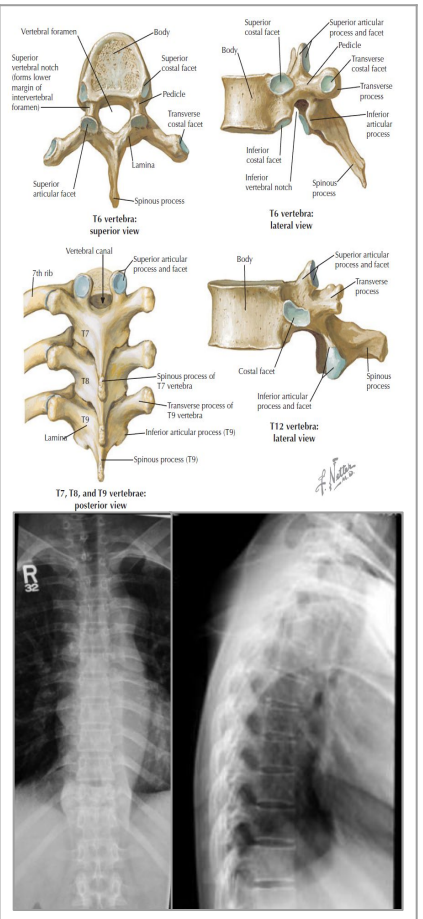


Anatomy:

Thoracic and Lumbar Vertebra

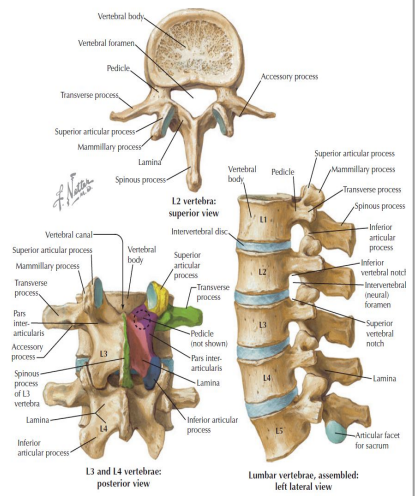
Thoracic Vertebra

- The thoracic vertebrae have 6 facets 2 superior & 2 inferior for attachment with vertebra above and below, and 2 costal for rib attachments which stabilize and splint and make it get more rigid. That's why most of the time it's treated conservatively unless it's a huge energy and significant disruption. Most of the injuries are at the junctional level of cervical or lumbar because thoracic is splint
- The superior and inferior facet orientation are aligned along the coronal plane (facing us) which limits its function to rotation
- **Function**: Rotation
- On x-ray we will see <u>square</u> shaped vertebral bodies and look for pedicles, on sagittal there is kyphosis, and on coronal it is straight.



Lumbar Vertebra

- Lumbar vertebrae are weight bearing bones.
- On x-ray they have box shaped body.
- Separation or widening of spinous process distance indicates possible injury.
- Any defect in pars reticularis will lead to spondylolisthesis.
- Function: Flexion and extension
  - Facet aligned along sagittal plane
- **Painful flexion** → discogenic problem
- **Painful extension** → pars interarticularis
- **Painful flexion and extension** → Spine motion segment.

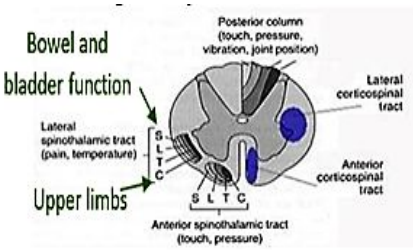


Intrinsic Pathways:

Spinal Tracts

There are 2 pathways in the spinal cord: ascending and descending tracts.

- Representation of nerve roots within tracts goes from cervical, thoracic, lumbar, sacral (CTLS) where cervical is more central and sacral is most peripheral.



So if the central part is affected how will it present?

- It will affect the upper limbs so there will be disproportionate upper limb weakness compared to lower limb.
- In thoracic representation trunk sensation and superficial/ abdominal reflexes will be affected.
- In lumbar representation lower limb function will be affected.
- In sacral representation bladder & bowel function will be affected.

If there is a posterior column issue, how will it present?

1. Gait will be affected (proprioception and joint position will be lost)
   ➔ Tested by Romberg test (+ve → swaying upon eyes closure)
2. Fine motor skills will be affected

Generally speaking if a patient has complete or almost complete spinal cord injury the last thing to be affected is the sacral representation which is responsible for bowel and bladder control.

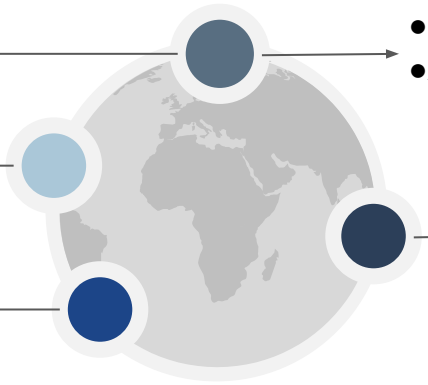
	Descending (motor)	Ascending (sensory)	
Tract	Corticospinal tract	Posterior column	Spinothalamic tract
Function	• Motor fibers	• Proprioception • Vibration • 2 point discrimination	• Pain • Temperature • Crude touch
Decussation	Decussate at brainstem	Decussate at brainstem	Decussate at spinal level
Lesion	**ipsilateral** UMN lesion (weakness, spasticity, increased reflexes, clonus, +ve Babinski)	**Ipsilateral** loss **below** the site of the lesion **Gait will be affected**	**Contralateral** loss **below** the site of the lesion.

Blood Supply

- The arterial blood supply to the spinal cord is derived from two branches of vertebral artery, the anterior and two posterior spinal arteries.
- So, **if anterior spinal artery is injured that's it, the anterior 2/3 of the spinal cord is infarcted. (important in anterior cord syndrome)**
- However posterior spinal infarctions are less common, due to the **dual** posterior spinal artery.

Epidemiology:

- 56000 cases per year.
- 11000 new spinal cord injuries.
- 25% have neurologic deficit
- Age: mostly between 15-24 years
- 15-20% multiple non-contiguous levels
- Gender: mostly males (4:1). Male are more into adrenaline rush and irresponsible driving
- 10% involving the cervical spine.
- 90% involving thoracolumbar spine



Spinal Red Flags:

Red Flags

① Cauda Equina:
- ➔ Severe neurologic injury sensory or motor loss: perianal numbness **(saddle paresthesia), urinary retention, stool incontinence**

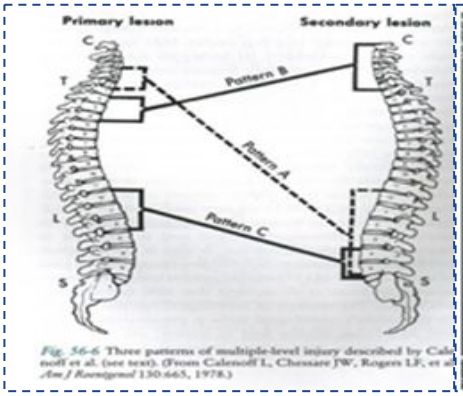
② Tumors:
- ➔ Weakening the vertebrae (causing cord compression or vertebral fracture)

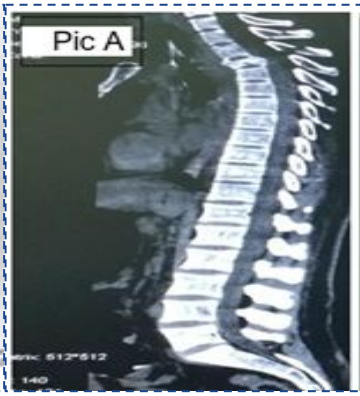
③ Infections: rigors and chills identify infections from tumors
- ➔ Weakening bone (causing disc/vertebral destruction or cord compression infection will lead to pus and the pus will compress the cord)

④ Traumatic Spine Fracture:
- ➔ Vertebral angulation, pain, or neuro compromise.

! Remember that spine fracture can occur without trauma
- **Low energy** → Infection/tumors
- **High energy** → Trauma

Mechanism of Injury





- There are 3 possible patterns of multiple non-contiguous level injury: pattern A, B, and C.
- If a patient presents with a primary lesion in the upper or lower cervical spine, he will also have a secondary lesion in the lumbar area (see pattern A)
- Picture A: A T3 fracture with mild subluxation and retropulsion of the fracture is shown. This is the image we received, is it enough?
- **NO** the patient might have a pattern B. We took a cervical image and found out that he did.

Injuries and Spinal Instability:

Trauma can be divided into high velocity (like skiing or falling from horse) or low velocity injury.

1. **High Energy Trauma** (such as: MVAs, fall from a height or horse)
   → MVA: 40-55% → Falls: 20-30% → Sports: 6-12% → Others: 12-21%
2. **Low Energy Trauma** i.e. patients with known risk factors such as:
   → Ankylosing spondylitis → Osteoporosis → Metastatic lesions
3. **Penetrating Trauma** from gunshots or knives

This is a pathological fracture in a patient with cervical **ankylosing spondylitis,** you can see loss of vertebral space and fusion of the vertebral bodies.

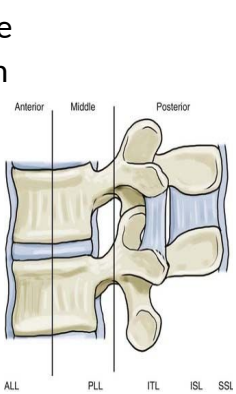
Spine Stability

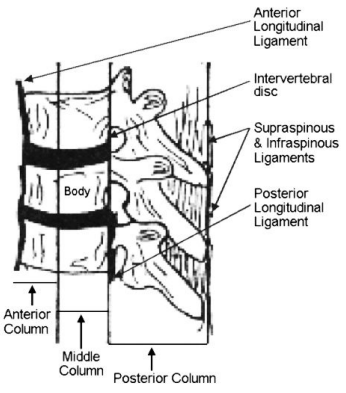
- There is cervical spine instability if:
  - ➔ Compression fracture with 25% loss of vertebral height.
  - ➔ Angular displacement > 11 degrees.
  - ➔ Translation > 3.5 mm
  - ➔ Disc space separation >1.7mm
- Thoracic and lumbar spine stability depends on Denis three column theory a Instability exists with disruption of any two of three columns (≥ 2 columns affected = instability)

Three Column Theory

Denis three column model divides the thoracolumbar spine into three columns. If 2 or more columns got affected by an injury it is considered an unstable injury.

- **Anterior column:** ALL → ½ vertebral body
- **Middle column:** ½ vertebral body → PLL
- **Posterior column: pedicles**, spinal cord, lamina, transverse processes, facet joints, spinous process, and the posterior ligaments (supraspinous, interspinous, and ligamentum flavum).





If the injury involved one third or less of the spine (= one column or less) - it is considered a "stable injury" and it is managed conservatively. If the injury involved two third or more of the spine - it is considered an "unstable injury" and it is managed by surgery.

Assessing Spinal Injuries:

ABCDEs

- In cases of trauma, **ABCDEs** [1] or **ATLS** must be assessed first and treated appropriately.
- Patients should be examined with a **spinal collar** until spinal pathology is excluded.

! Careful **log rolling** by keeping the head, neck and pelvis in line should be done to examine the spine properly. (log rolling is used to immobilize the patient)

Immobilization

- When the paramedics arrive at the scene, they need to examine the scene carefully, place a cervical collar (hard collar) on the patient and transport him via a spine board (only used to transport) through log rolling.
- Prolonged stay on the spinal board can lead to ulcers in the back; while log rolling [2,3] prevents them.


History

- Mechanism of injury: compression, flexion, extension, distraction.
- Seat belt (People who are wearing a lap belt only → can lead to chance injury)
- Other injuries.
- Other casualties

Physical Examination

- **We test each dermatome, myotome and reflex.**
- Inspection (ecchymosis, swellings, open wound…)
- Palpation (tenderness)
- Neurologic examination:
  - ➔ Muscle Test
  - ➔ Sensory exam: light touch, sharp and dull discrimination, vibration sense, proprioception and two- point discrimination.
  - ➔ Reflexes

1- A in ABCDE stands for airway and inline mobilization of cervical spine.
2- Cervical collar can immobilize the cervical spine. Log rolling is the best way to immobilize the whole spine and prevent the formation of pressure ulcers especially among patients placed on spinal board (don't put the patient for more than 8 hrs)
3- Logrolling requires at least 3 people and preferably 4.
4- The image shows a transport hard collar and should be replaced with philadelphia's collar upon hospital admission

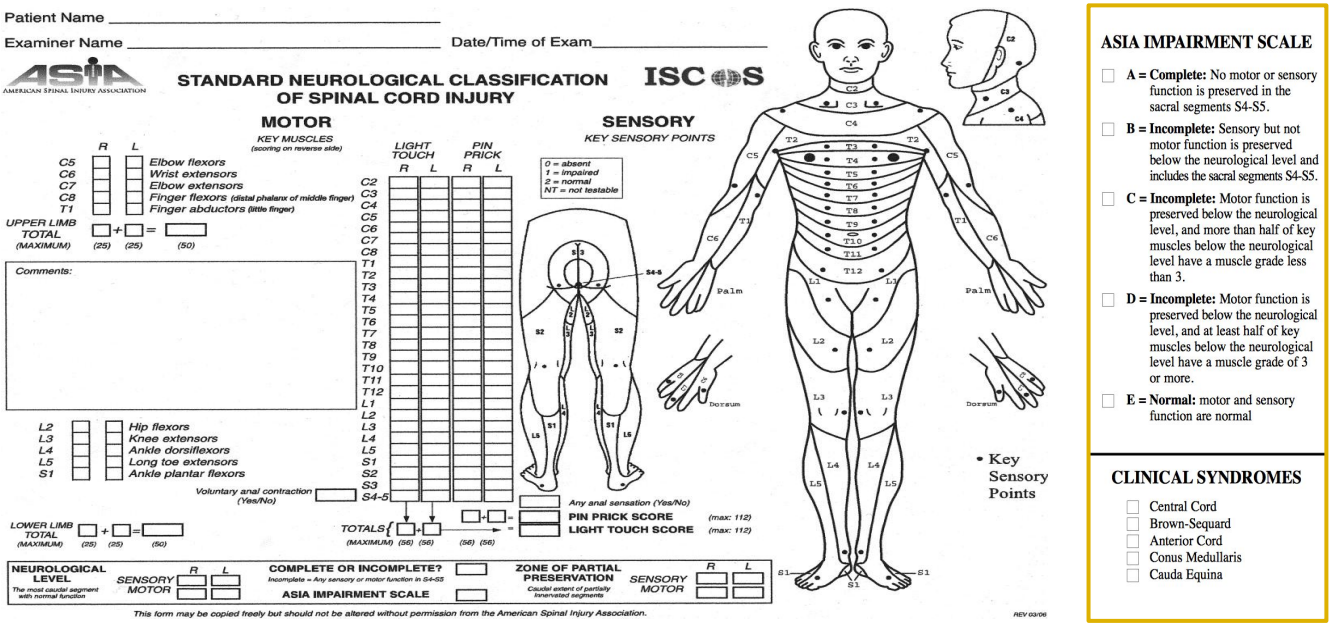
Assessing Spinal Injuries:

Signs of Spinal Trauma

- Apnea (diaphragm may be affected), lower cranial nerve injury VIII-XII (high C-spine) which is mainly occipito-cervical.
- Deformity of the spine or neck.
- Tenderness on palpation along spinal processes.
- Paralysis or muscle weakness (which spinal level?)
- Loss of sensation (which dermatomes?)
- Loss of rectal tone
- Positive Babinski sign or plantar response (brainstem injury = UMN)

American Spinal Injury Association (ASIA) Score

- ASIA Score Brief Trauma Neurologic Survey[4] evaluates sensation and motor function of nerve roots
- It requires assessing all dermatomes [1], myotomes [2], and reflexes [3] and giving a score as (A, B, C, D, E). You also need to classify him into one of the clinical syndromes provided.



Prognosis for Spinal Recovery

- **Poor** prognosis for recovery if:
  - ➔ Patient arrives in shock.
  - ➔ Patient cannot breathe.
  - ➔ Patient has a complete injury

1-Areas assigned by dots are important and sensitive in exam u have to **know general dermatomes** but specifically the dotted areas
2- Important myotomes → L2 hip flexion, L3 knee extension, L4 ankle dorsiflexion, L5 hallucis longus extensor, S1 plantar flexion.
3- Knee reflex is done by L4
4- The final ASIA impairment score should be given after the resolvement of the spinal shock (~72 hrs) and the return of the bulbocavernosus reflex. Before this, you can classify the patient into one of the clinical syndromes shown.

Assessing Spinal Injuries:

Severity of Neurological Deficit

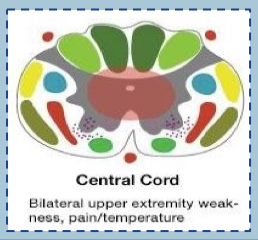
- Based on the pattern of neurological deficit we can classify spinal injuries into:

Complete

- Flaccid paralysis below level of injury (initially flaccid paralysis and spasticity later)
- May involve diaphragm (if injury above **C5**, C3-C5 injuries might require a ventilator)
- Sympathetic tone loss if fracture above **T6** (neurogenic shock)

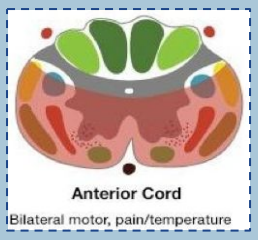
Incomplete
(Any sensation or sacral sparing)

Central Cord Syndrome



- Characterized by disproportionally (**UL>LL**) the distal affected more than the proximal structures
- **Mechanism**: hyperextension
- Occur with or without fractures.
- **Recovery**: 50% regaining function
- **Prognosis is fair**

Anterior Cord Syndrome

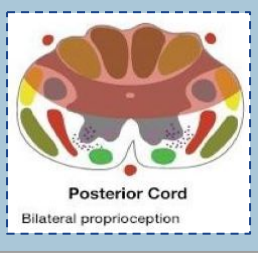


- Characterized by loss of corticospinal (motor) and spinothalamic (pain, temperature) tract with preserved posterior column (proprioception, vibratory sense).
- **Mechanism**: ischemia or infarction to spinal cord
  - Anterior spinal artery → due to injury, infection, abscess, tumor
- Common injury
- **Recovery:** 10%
- Prognosis is good if progressive recovery within 24hrs, absent Sacral sparing after 24hrs pretends a poor outcome.
- Rapid loss of function = vascular related injury

Brown Sequard Syndrome

- Characterized by hemicord injury with ipsilateral paralysis, loss of proprioception and light touch (dorsal column), and contralateral temperature and sharp pain loss (spinothalamic)
- Caused by disc, tumor, fracture, or hemicord transection
- Anything other than transection has good prognosis,
  - With over 90% regaining of bowel and bladder function and ambulatory capacity

Extra
Posterior Cord Syndrome

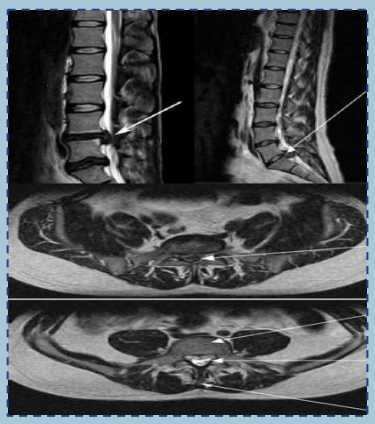


- Extremely rare, vascular compromise appears to be the most common etiology. With occlusion to the posterior spinal artery.
- Patient will have loss of proprioception which will affect gait and fine hand movements (as discussed above).

Assessing Spinal Injuries:

Severity of Neurological Deficit

- Based on the pattern of neurological deficit we can classify spinal injuries into:

Incomplete (Any sensation or sacral sparing)	
Nerve Root Deficit	• Presents as a LMN lesion with radiculopathy • For example, an L4 lesion will present with an ipsilateral weakness in knee reflex and knee extension along with loss of sensation along L4 dermatome.
Cauda Equina Syndrome 	• Sudden saddle anesthesia, urinary retention and bowel incontinence (absence of such Sx = radiculopathy) • Usually caused by a large disc herniation rather than a fracture • Can be caused by other things such as tumors, epidural hematoma, and spinal stenosis • Requires full neurological examination and rectal examination for anal tone. • Initial X-ray must be done followed by an MRI (best). If we cannot perform an MRI **we do CT** (pacemakers, gunshot wounds…) • It is a surgical emergency by performing a discectomy and wide laminectomy within 24 hours **(emergent decompression)**
Conus Medullaris Syndrome	• Conus medullaris: It is the terminal part of the spinal cord around T12/L1. • It is the area between spinal cord and the cauda equina. • Injury results in loss of voluntary bowel and bladder control with preserved lumbar root function, fasciculations and signs of UMN lesions (hyperreflexia…) • Uncommon as pure lesion (mixed conus-cauda)

	Conus Medullaris	Cauda Equina
Pain	Less common & less severe, LBA	Pain is prominent, severe & radicular in type;
Location	Bilateral and symmetric; in perineum or thighs	Unilateral or asymmetric; in perineum, thighs, legs, or back;
Sensory deficit	Saddle distribution; Bilateral, usually symmetric; Dissociation of sensation	Saddle distribution; Unilateral and asymmetric; No dissociation of sensation
Motor loss	Symmetric; Not marked; Fasciculations may be present	Asymmetric; More marked; atrophy may occur; usually no fasciculations
Reflex loss	Only Ankle reflex absent	Knee and Ankle reflexes may be absent
Bladder and rectal symptoms	Early and marked	Late and less marked
Trophic changes	Common	Less common
Sexual functions	Erection and ejaculation impaired	Less marked impairment
Onset	Sudden and bilateral	Gradual and unilateral

Assessing Spinal Injuries:

Types of Shock

Spinal Shock	Neurogenic Shock
• Transient loss of spinal reflexes. • Physiologic shutdown of all spinal cord (sensory, motor, reflexes) function below the level of injury. • Lasts **24-72** hours. **How** do I know if spinal shock is over? By the return of the **bulbocavernosus reflex**[1]	• Vascular phenomenon caused by lesions above T6 • Results in reduced tissue perfusion due to loss of sympathetic outflow and unopposed vagal tone. • Peripheral vasodilatation (hypotension and bradycardia) • Rx: **fluid resuscitation** initially and **vasopressors (MUST)**

Imaging

X-ray:

- Cervical: 3 views (AP, lateral and open mouth (dens)
- Thoracolumbar: 2 views (AP and lateral)
  - Flexion and extension views NOT IN TRAUMA

CT:

- Best for bony anatomy (burst fractures)

MRI:

- Best for soft tissue evaluation

Management

Management depends on:

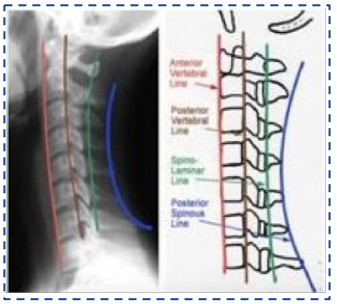
1. Level of injury(C3 Vs. L5? totally different consequences).
2. Degree and morphology of injury: **STABILITY**.
3. Presence of neurologic deficit.
4. Other factors (Pathological fracture vs. High energy trauma)

General Rules:

- **Stable** injuries are usually treated **conservatively**
- **Unstable** injuries usually require **surgery**
- Neurologic compression requires decompression

1- Squeezing the glans penis (Or the clitoris) leads to contraction of the anal sphincter. When present, it is indicative of intact spinal reflex arcs (S2–S4 spinal segments) with afferent and efferent nerves through the pudendal nerve.

Specific Injuries:



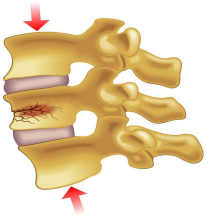
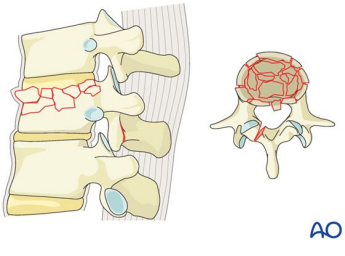
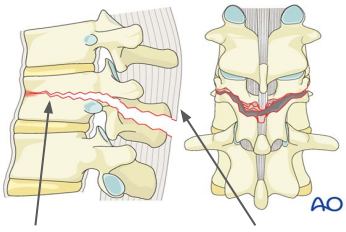
Normal cervical x-ray
Anterior and Posterior line should be congruent

1- Cervical Spine Fractures:

- Descriptive: depends on mechanism of injury:
  - Flexion/extension. (horse riding)
  - Compression/distraction.
  - Shear.
- Presence of subluxation/dislocation.
- SCI spinal cord injury:
  - High fracture (upper in cervical) results in **quadriplegia**
  - High fractures requires ventilators.
  - Low fracture (lower in thoracic) results in **paraplegia.**
- If a pt presented with cervical fracture/dislocation:
  - Symptoms: can't move, can't feel, neck pain
  - Signs (go with the symptoms): paralysis, loss of sensation, ecchymosis...

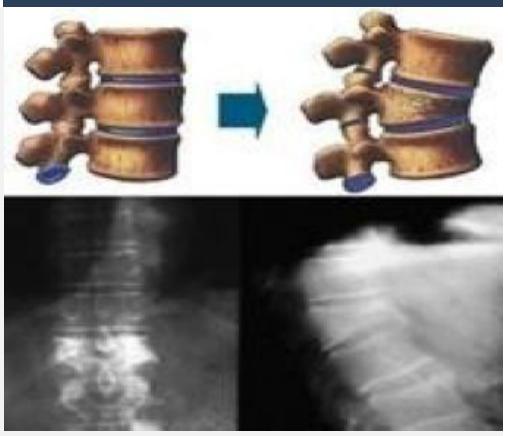
C5/6 fracture dislocation (**Unstable**)
Could be quadriplegic, paraplegic, or have initial presentation of spinal shock

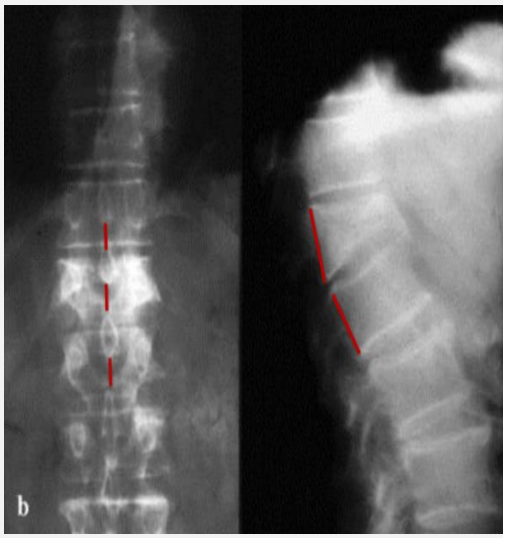
2- Thoracolumbar Fractures:

Thoracolumbar Fractures		
	• Spinal cord terminates at L1/L2 (L2/L3 in children) • 50% of injuries occur at the thoracolumbar junction (T12/L1)	
Wedge Fracture	• Most common fracture due to severe spinal flexion • Anterior part is compressed and posterior is intact and distance b/w spinous processes are normal • Only the anterior column is affected so the spine is stable	
Burst Fracture	• Severe axial compression may 'explode' the vertebral body • Both anterior and posterior parts of the spine are affected and there's spinous process widening • The whole vertebral body is affected (unstable)	 AO
Chance Fracture	• Hyperflexion injury can affect the bones and ligaments • This is a three columns injury = unstable injury. • 40% associated w/ abdominal injury = bowel perforation, mesenteric rupture or bowel rupture. • Mechanism? Wearing only lap belt. • Children must either be in a car seat or have a seat booster to prevent these types of injuries	On ALL is intact  AO Bony chance Ligamentum chance

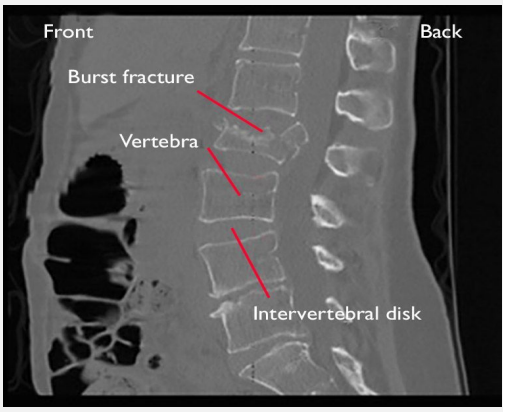
Specific Injuries:

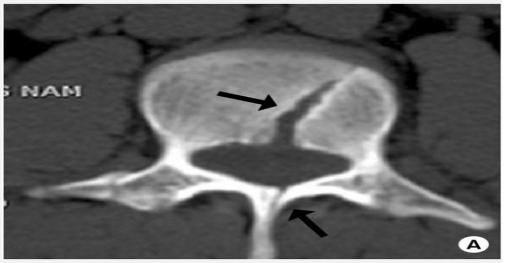
Wedge Fractures





Burst Fractures

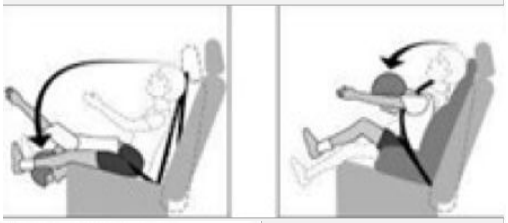


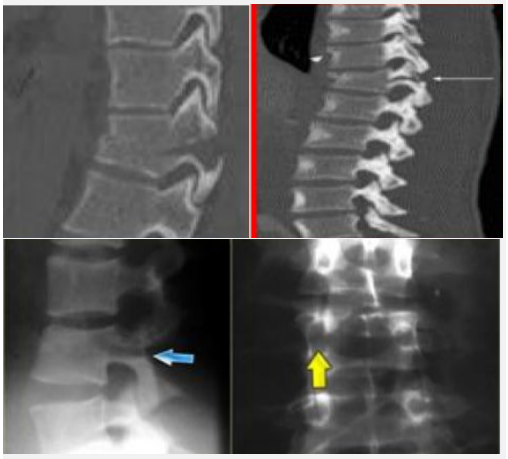


Burst fracture - characteristics

1. Retropulsion of posterosuperior vertebral body fragment (wedge compression may bulge posterior cortex but not posteriorly displace)
2. Sagittal fracture of vertebra 90%
3. Sagittal posterior fracture 85%
4. Widened interpedicular distance 80%

Chance Fractures

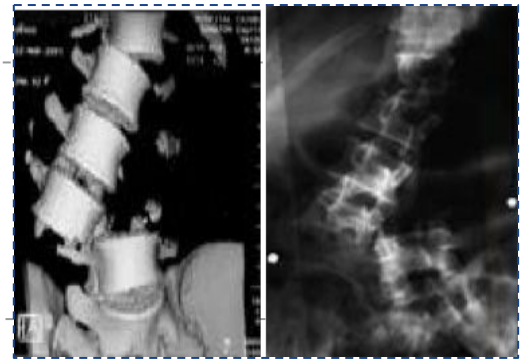




One pedicle is longer than the other

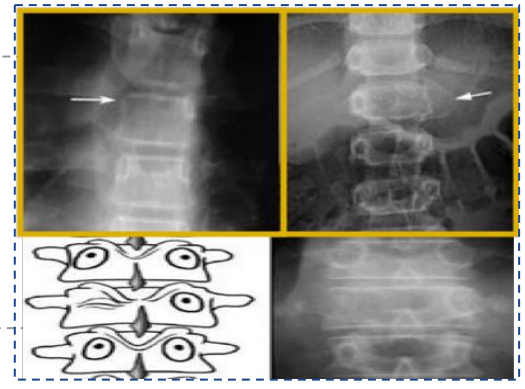
3- Fracture Dislocation:

- Unstable = all three columns are disrupted
- These are the most dangerous injuries and are often associated with neurological damage to the lowermost part of the cord or the cauda equina.
- There will be coronal and sagittal loss of alignment on X-ray

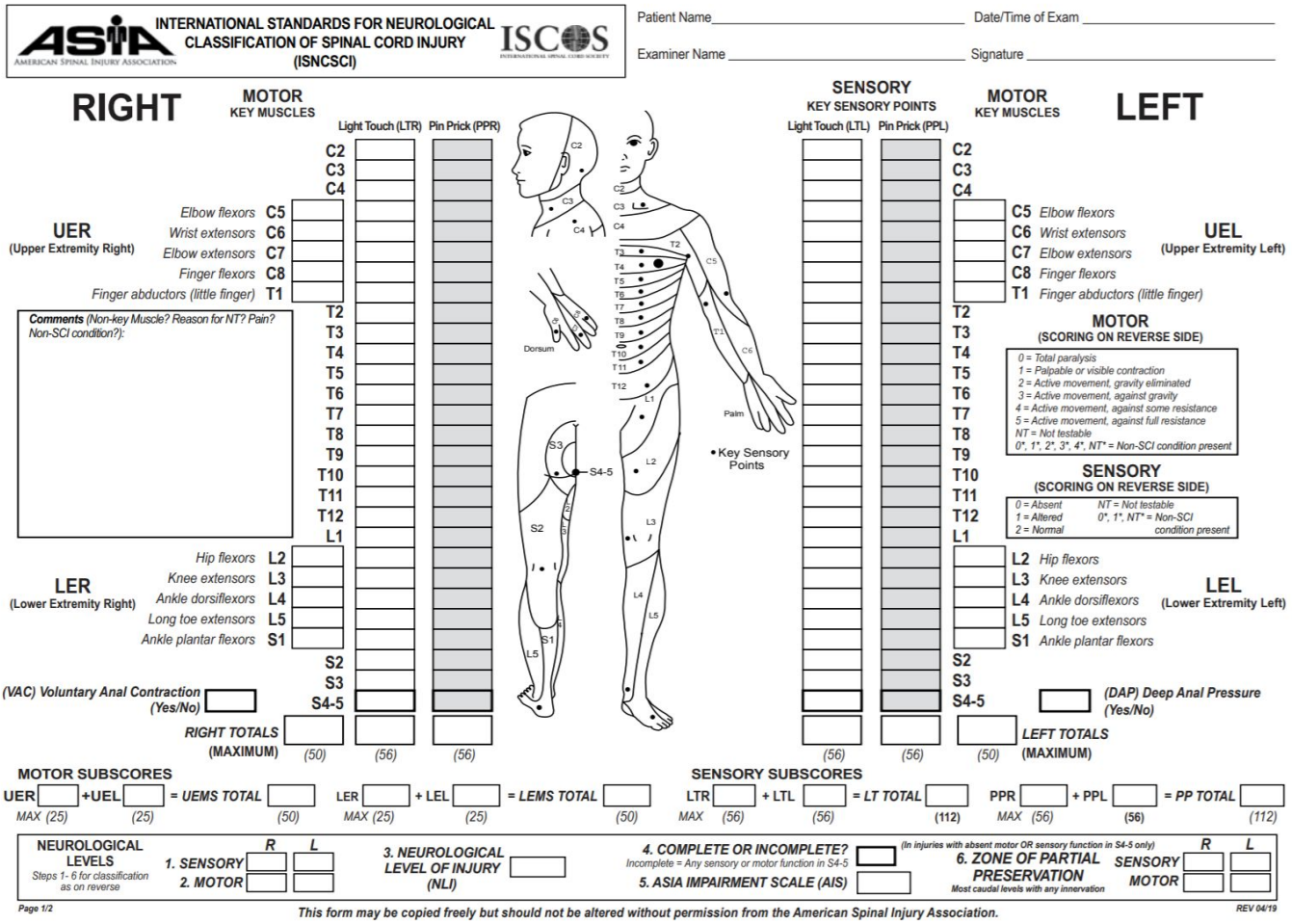


4- Pathological Fractures:

- Usually due to infection or tumor.
- Low-energy fractures.
- Osteoporosis is the **most common cause**
- X-rays **winking owl** sign (pathognomonic for infection or tumor) (absent pedicles) it's a prefracture sign
- You need to treat the fracture and the underlying cause



Extra:



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

INTERNATIONAL SPINAL CORD SOCIETY

Page 2/2

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".

Extra:

Spine

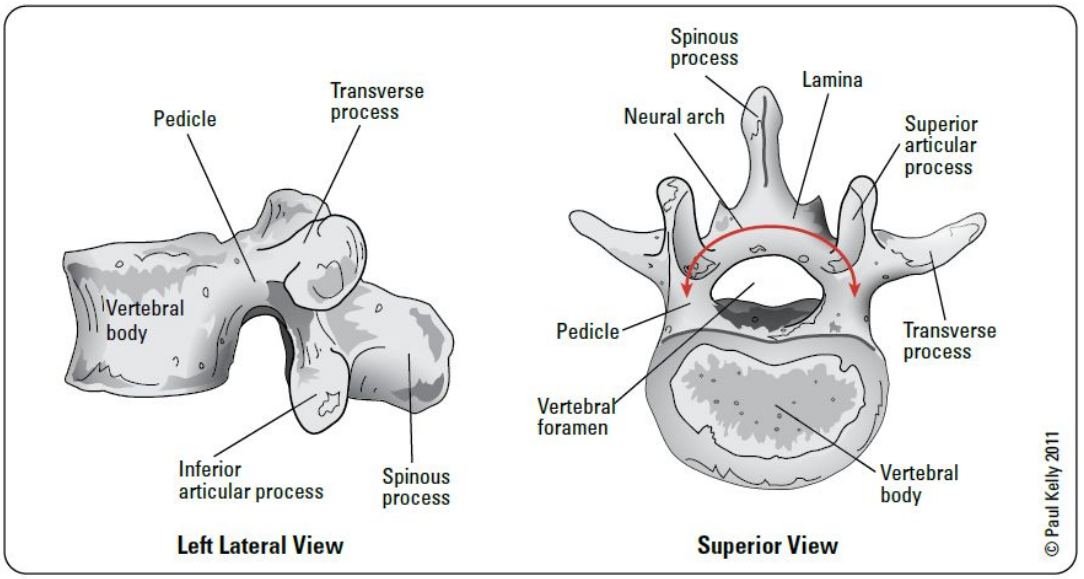


Figure 27. Schematic diagram of vertebral anatomy
Adapted from: Moore KL, Agur AMR. Essential Clinical Anatomy, 3rd ed. Philadephia: Lippincott Williams and Wilkins, 2007. p274

Fractures of the Spine

- see Neurosurgery, NS34

Cervical Spine

General Principles

- C1 (atlas): no vertebral body, no spinous process
- C2 (axis): odontoid = dens
- 7 cervical vertebrae; 8 cervical nerve roots
- nerve root exits above vertebra (i.e. C4 nerve root exits above C4 vertebra), C8 nerve root exits below C7 vertebra
- radiculopathy = impingement of nerve root
- myelopathy = impingement of spinal cord

Special Testing

- compression test: pressure on head worsens radicular pain
- distraction test: traction on head relieves radicular symptoms
- Valsalva test: Valsalva maneuver increases intrathecal pressure and causes radicular pain

Table 14. Cervical Radiculopathy/Neuropathy

Root	C5	C6	C7	C8
Motor	Deltoid Biceps Wrist extension	Biceps Brachioradialis	Triceps Wrist flexion Finger extension	Interossei Digital flexors
Sensory	Axillary nerve (patch over lateral deltoid)	Thumb	Index and middle finger	Ring and little finger
Reflex	Biceps	Biceps Brachioradialis	Triceps	Finger jerk

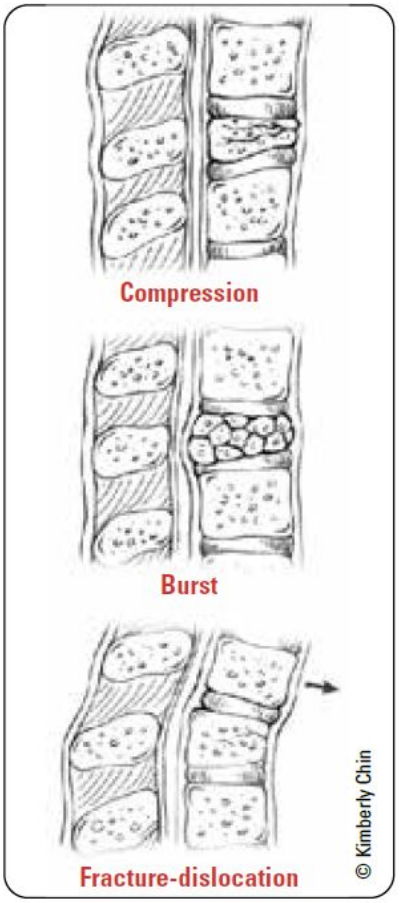


Figure 26. Compression, burst, and dislocation fractures of the spine

Extra:

X-Rays for C-Spine
- AP spine: alignment
- AP odontoid: atlantoaxial articulation
- lateral
  - vertebral alignment: posterior vertebral bodies should be aligned (translation >3.5 mm is abnormal)
  - angulation: between adjacent vertebral bodies (>11° is abnormal)
  - disc or facet joint widening
  - anterior soft tissue space (at C3 should be ≤3 mm; at C4 should be ≤8-10 mm)
- oblique: evaluate pedicles and intervertebral foramen
- ± swimmer's view: lateral view with arm abducted 180° to evaluate C7-T1 junction if lateral view is inadequate
- ± lateral flexion/extension view: evaluate subluxation of cervical vertebrae

Differential Diagnosis of C-Spine Pain
- neck muscle strain, cervical spondylosis, cervical stenosis, RA (spondylitis), traumatic injury, whiplash, myofascial pain syndrome, acute discogenic nerve root entrapment, infection, fracture, neoplasm, pain from soft tissue structure

Spinal Cord Injury

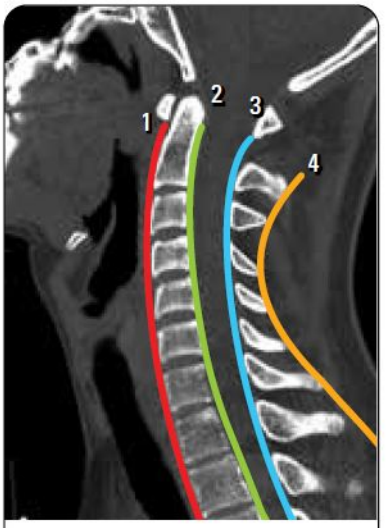
- see Orthopaedic Surgery, OR24 and Emergency Medicine, ER9

Neurogenic and Spinal Shock
1. neurogenic shock: hypotension that follows SCI (sBP usually ≤80 mmHg) caused by
   - interruption of sympathetics (unopposed parasympathetics) below the level of injury
   - loss of muscle tone due to skeletal muscle paralysis below level of injury → venous pooling (relative hypovolemia)
   - blood loss from associated wounds (true hypovolemia)
2. spinal shock: transient loss of all neurologic function below the level of the SCI, causing flaccid paralysis and areflexia for variable periods

Whiplash-Associated Disorders
- definition: traumatic injury to the soft tissue structures in the region of the cervical spine due to hyperflexion, hyperextension, or rotational injury to the neck

Initial Management of Spinal Cord Injury
- major causes of death in SCI are aspiration and shock
- the following patients should be treated as having a SCI until proven otherwise:
  - all victims of significant trauma
  - minor trauma patients with decreased LOC or complaints of neck or back pain, weakness, abdominal breathing, numbness/tingling, or priapism

Stabilization and Initial Evaluation in the Hospital
1. ABCs, immobilization (backboard/head strap), oxygenation, Foley catheter to urometer, temperature regulation
2. hypotension: maintain sBP >90 mmHg with pressors (dopamine), hydration, and atropine
   - Deep vein thrombosis (DVT) prophylaxis
3. monitor CBC/electrolytes
4. perform a mental status and cranial nerve function assessment as many patients with SCI have co-occurring traumatic brain injury
5. focused history and exam as the patient is being immobilized (see *Trauma Assessment*, NS30)
6. spine palpation: point tenderness or deformity
7. motor level assessment (including rectal exam for voluntary anal sphincter contraction)
8. sensory level assessment: pinprick, light touch, and proprioception
9. evaluation of reflexes
10. signs of autonomic dysfunction: altered level of perspiration, bowel or bladder incontinence, priapism
11. radiographic evaluation
    - 3 views C-spine x-rays (AP, lateral, and odontoid) to adequately visualize C1 to C7-T1 junction
    - flexion-extension views to disclose occult instability
    - CT scan (bony injuries) typically most trauma centres use CT as the modality of choice for looking at fractures, very sensitive with the high resolution scanners
    - MRI mandatory if neurological deficits (soft tissue injuries)



ABCDS

Alignment
columns
anterior vertebral line (1)
posterior vertebral line (2)
spinolaminar line (3)
posterior spinous line (4)

Bone
vertebral bodies
facets
spinous processes

Cartilage

Disc
disc space
interspinous space

Soft tissues

Pre-vertebral soft tissues (A)

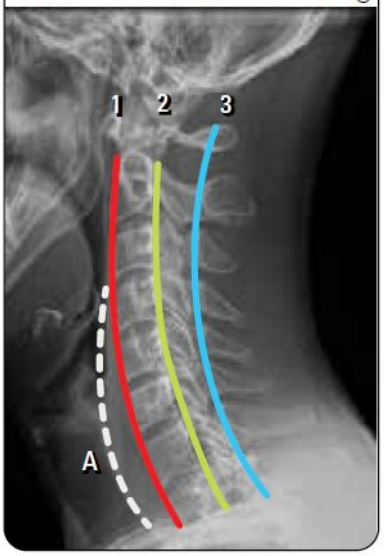


Figure 28. Assessment of spine CT/X-Ray (parasagittal view)
Images used with permission from Dr. Ferco Berger and Dr. Michael O'Keeffe

Extra:

Medical Management Specific to Spinal Cord Injury

- option: methylprednisolone (given within 8 h of injury) this is controversial and you need to confer with Neurosurgery service
- ± decompression in acute, non-penetrating SCI

Fractures of the Spine

FRACTURES AND FRACTURE-DISLOCATIONS OF THE THORACIC AND LUMBAR SPINE

- assess ligamentous instability using flexion/extension x-ray views ± MRI
- thoracolumbar spine unstable if 4/6 segments disrupted (3 columns divided into left and right)
  - anterior column: anterior half of vertebral body, disc, and anterior longitudinal ligament
  - middle column: posterior half of vertebral body, disc, and posterior longitudinal ligament
  - posterior column: posterior arch, facet joints, pedicle, lamina and supraspinous, interspinous, and ligamentum ligaments

Types of Injury

Table 21. Denis Classification of Spinal Trauma

Fracture Type	Description
Compression Fracture (58%)	Produced by flexion Posterior ligament complex (supraspinous and interspinous ligaments, ligamentum flavum, and intervertebral joint capsules) remain intact Fractures are stable but lead to kyphotic deformity
Burst Fracture (17%)	Stable: anterior and middle columns parted with bone retropulsed nearby Hallmark is pedicle widening on AP x-ray Spinal cord (seen on x-ray and CT); posterior column is uninjured Unstable: same as the stable but with posterior column disruption (usually ligamentous)
Flexion Distraction Injury (6%)	Hyperflexion and distraction of posterior elements Middle and posterior columns fail in distraction Classic: Chance, horizontal fracture through posterior arch, pedicles, posterior vertebral body Can be purely ligamentous, i.e. through PLL and disc
Fracture-Dislocation (6%)	Anterior and cranial dislocation of superior vertebral body → 3 column failure Three types: (1) flexion-rotation, (2) flexion-distraction, (3) shear/hyperextension (rare)

Management of Thoracolumbar Injury

- severity and management based on thoracolumbar injury classification and severity (TLICS) classification

FRACTURES OF THE CERVICAL SPINE

Types of Injury

Table 22. Fracture Patterns of the Cervical Spine

Fracture Type	Description
C1 Vertebral Fracture (Jefferson fracture)	Vertical compression forces the occipital condyles of the skull down on the C1 vertebra (atlas), pushing the lateral masses of the atlas outward and disrupting the ring of the atlas Also can cause an occipital condylar fracture
Odontoid Fracture	Causes C1 and odontoid of C2 to move independently of C2 body This occurs because Normally C1 vertebra and odontoid of C2 are a single functional unit Alar and transverse ligaments on posterior aspect of odontoid usually remain intact after injury Patients often report a feeling of instability and present holding their head with their hands Type II fracture the most common
C2 Vertebral Fracture (hangman fracture)	Bilateral fracture through the pars interarticularis of C2 with subluxation of C2 on C3 (spondylolisthesis of axis) Usually neurologically intact
Clay-Shoveler Fracture	Avulsion of spinous process, usually C6 or C7

Imaging

- AP spine x-ray (open-mouth and lateral view), CT

Treatment

- immobilization in cervical collar or halo vest until healing occurs (usually 2-3 mo)
- Type II and III odontoid fractures: consider surgical fixation for comminution, displacement, or inability to maintain alignment with external immobilization
- confirm stability after recovery with flexion-extension x-rays

Resolution of spinal shock is indicated by the return of reflexes (most commonly the bulbocavernous reflex)

Pharmacological Therapy for Acute Spinal Cord Injury: Congress of Neurological Surgeons (CNS) and American Association of Neurological Surgeons (AANS) Guidelines
Neurosurgery 2013;72(Suppl 2):93-105
Level I Recommendations

- No Class I or Class II medical evidence supports the use of methylprednisone in the treatment of acute SCI. Several Class II and Class III studies have been published stating inconsistent effects of methylprednisone likely related to random chance or selection bias.
- Administration of GM-1 ganglioside (Sygen) for the treatment of acute SCI is not recommended.

Early vs. Delayed Decompression for Traumatic Cervical Spinal Cord Injury: Results of the Surgical Timing in Acute Spinal Cord Injury Study (STASCIS)
PLoS ONE 2012;7:e32037
Purpose: This study sought to determine the relative effectiveness of early (<24 h after injury) vs. late (≥24 h after injury) decompressive surgery following a traumatic cervical SCI.
Methods/Population: A prospective cohort study completed in 2002-2009 involving 6 North American institutions. Participants were 16-80 yr with a cervical SCI. Outcomes evaluated were changes in American Spinal Injury Association Impairment Scale (AIS) grade at 6 mo follow-up, complication rates, and mortality.
Results: Of 313 participants enrolled, 182 underwent early surgery and 131 underwent late surgery. 222 participants were available for follow-up at 6 mo. The odds of at least 2 grade AIS improvement were greater for those who had early surgery compared to those with late surgery (OR 2.83, 95% CI 1.10, 7.28) after adjusting for preoperative neurological status and steroid administration. Mortality was observed for each group during the first 30 d post injury, only 1 mortality occurred in both of the surgical groups. No statistically significant differences were observed for complications (P=0.21).
Conclusion: Early decompression surgery following a SCI is safe and associated with higher AIS improvement at 6 mo following injury.

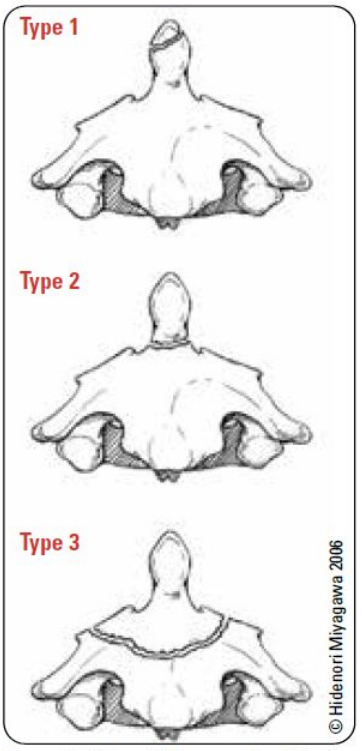


Figure 29. Odontoid fracture classification

Extra:

Spinal Cord Syndromes

Complete Spinal Cord Lesion

- bilateral loss of motor/sensory and autonomic function at ≥4 segments below lesion/injury, with UMN signs
- about 3% of patients with complete injuries will develop some recovery within 24 h, beyond 24 h, no distal function will recover

Incomplete Spinal Cord Lesion

- any residual function at ≥4 segments below lesion
- signs include sensory/motor function in lower limbs and "sacral sparing" (perianal sensation, voluntary rectal sphincter contraction)

Table 18. Comparison Between Incomplete Spinal Cord Lesion Syndromes

Syndrome	Etiology	Motor	Sensory
Brown-Séquard	Hemisection of cord	Ipsilateral LMN weakness at the lesion Ipsilateral UMN weakness below the lesion	Ipsilateral loss of vibration and proprioception Contralateral loss of pain and temperature Preserved light touch
Anterior Cord	Anterior spinal artery compression or occlusion	Bilateral LMN weakness at the lesion Bilateral UMN weakness below the lesion Urinary retention	Preserved vibration and proprioception Bilateral loss of pain and temperature Preserved light touch
Central Cord (most common)	Syringomyelia, tumours, spinal hyperextension injury	Bilateral motor weakness: Upper limb weakness (LMN lesion) > Lower limb weakness (UMN lesion) Urinary retention	Variable bilateral suspended sensory loss Loss of pain and temperature > loss of vibration and proprioception
Posterior Cord	Posterior spinal artery infarction, trauma	Preserved	Bilateral loss of vibration, proprioception, light touch at and below the lesion Preserved pain and temperature

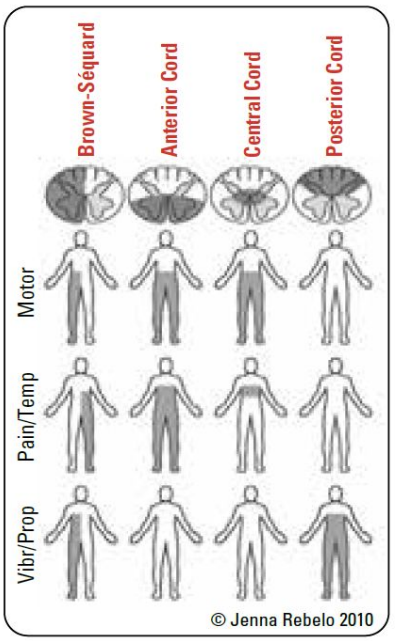


Figure 25. Spinal cord lesion syndromes

Guideline for Timing of Decompressive Surgery in Management of Acute Spinal Cord Injury and Central Cord Syndrome: Results of a Systematic Review

Global Spine Journal 2017;7(3S):195S-202S

Summary of recommendations:

- Low quality of evidence: Early surgery (<24 h after injury) should be considered as a treatment option in adult patients with traumatic central cord syndrome.
- Low quality of evidence: Early surgery should be offered as an option for adult acute SCI patients, regardless of level of lesion.

Cauda Equina Syndrome

Etiology

- compression or irritation of lumbosacral nerve roots below conus medullaris (below L2 level)
- decreased space in the vertebral canal below L2
- common causes: herniated disc ± spinal stenosis, vertebral fracture, and tumour

Clinical Features

- usually acute (develops in less than 24 h); rarely subacute or chronic
- motor (LMN signs)
  - weakness in multiple root distribution
  - reduced deep tendon reflexes (knee or ankle)
- autonomic
  - urinary retention (or overflow incontinence) and/or fecal incontinence due to loss of anal sphincter tone
- sensory
  - low back pain radiating to legs (sciatica) aggravated by Valsalva maneuver and by sitting; relieved by lying down
  - bilateral sensory loss or pain: depends on the level affected
  - saddle area (S2-S5) anesthesia
  - sexual dysfunction (late finding)

Investigations

- urgent MRI to confirm compression of S2-S3-S4 nerve root by a large disc herniation
- post-void residual very helpful to determine if true retention is present; volumes controversial but anything over 250 cc in a healthy individual is cause for concern

Causes of Cauda Equina Syndrome

- Lumbar disc herniation
- Spinal stenosis
- Spinal tumour
- Epidural abscess
- Hematoma
- Trauma

Quiz

MCQ

Q1: 8 years old boy was heading to school with his father by car , they had an accident the father has hip dislocation, after taking a detailed history , we knew that the boy was setting in the front seat with a seatbelt (lab belt) . What type of injury do you think the boy has ?

A. Cervical fracture
B. Head injury
C. Fractured femur
D. Abdominal injury

Q2: when can we classify spinal injuries by using ASIA score ?

A. After normal motor & sensory function
B. After normal rectal tone
C. After normal bulbocavernosus reflex
D. After neurogenic shock resolvement

Q3: A 52 years old male is involved in an altercation where his neck was twisted and extended with force. Upon presentation he complains of neck pain , and loss of ability to stand or ambulate. On physical exam, he has Grade 3 motor strength in the majority of his muscles groups upper & lower limbs. His sensory is intact in all four extremities,and his bulbocavernosus reflex is intact.
Where does the patient neurological condition classify in ASIA score ?

A. ASIA B
B. ASIA C
C. ASIA D
D. ASIA E

Q4: what do we use to immobilize trauma patients ?

A. Spinal collar
B. Spinal board
C. Leg rolling
D. Jaw thrust technique

Q5 what is the most common location of thoracolumbar fractures ?

A. Thoracolumbar junction
B. T12 , L1
C. L2 , L3
D. Lumbosacral junction

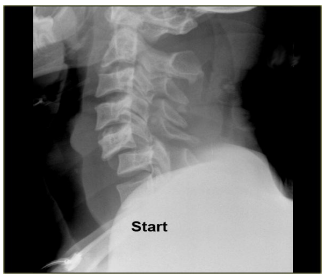
Answers

Q1	Q2	Q3	Q4	Q5
D	C	C	C	A

Quiz

SAQs

A 46 years old gentleman was riding a horse and he fell into his neck , an ambulance picked him to the nearest emergency hospital , Xray and CT was done shown below



1. What are the possible symptoms patient might have ?
2. What are the possible signs patient might have ?
3. How would you manage this patient (sequence of actions, ordres, …) ?

Answers

1. Neck pain , numbness , weakness , paralysis
2. Apnea , neck tenderness, loss of sensation , muscle weakness,
3. Manage as trauma patient (ATLS)
   - Secure airway and inline stabilization of the spine (collar)
   - Insure good oxygenation (breathing)
   - Stop bleeding if its there and maintain BP (circulation)
   - Give IVF and Vasopressors.
   - Surgery as this fracture is unstable.

   History & Physical exam
   ASIA score if the bulbocavernosus reflex is intact
   Imaging (Xray, CT)

General role: - stable patient ---------> conservative
- unstable patient ---------> surgery

THANK YOU

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