



433 Teams

# ORTHOPEDICS

Lecture (5)

## Acute Spinal Injuries & Cauda Equina Syndrome

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## Spine Pathology Red flags (Emergency) Conditions



- 1) **Cauda Equina/severe neurologic injury** (e.g. perianal numbness, decreased rectal tone, loss of movement in the extremities).
- 2) **Tumor** weakening the vertebrae (causing cord compression or vertebral fracture).
- 3) **Infection** weakening bone (causing disc/vertebral destruction or cord compression).
- 4) **Traumatic spine fracture** (causing vertebral angulation, pain, or neuro compromise). "However, spine fracture can also occur without trauma"

## Anatomy of the Spine

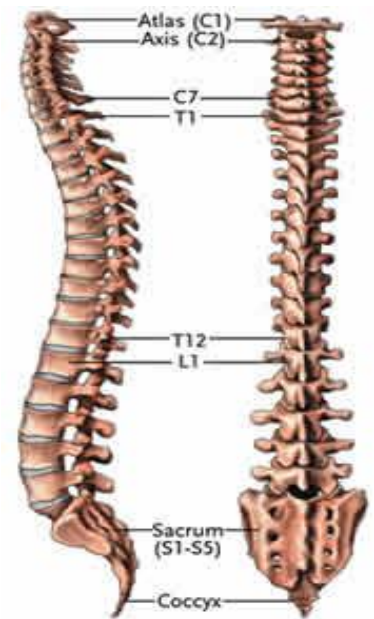
"Make sure you understand anatomy well"

On a coronal plane, the anatomy of the spinal column shows

- Seven Cervical vertebrae.
- Twelve Thoracic vertebrae.
- Five Lumbar vertebrae.
- Five Sacral vertebrae (fused.)
- Three Coccygeal vertebrae (fused.)

On a sagittal plane, the anatomy of the spinal column shows

- Secondary Cervical lordosis.
- Primary Thoracic kyphosis.
- Secondary Lumbar lordosis.
- Primary Sacral and coccygeal kyphosis



Lateral and posterior view of the spine

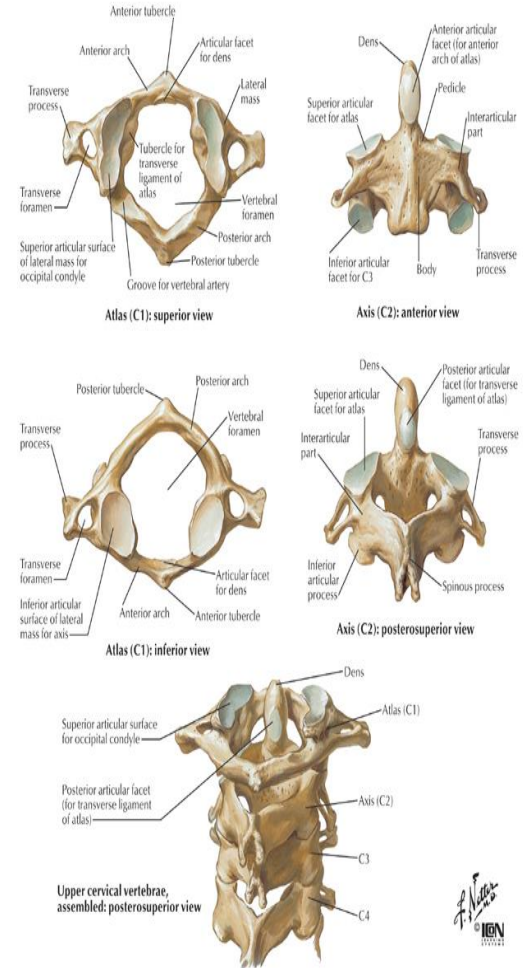
1/Kyphosis: refers to the convex curvature of the spine as it occurs normally in the thoracic and sacral regions. It is primary because the fetus in utero has a kyphotic spine in all regions.

2/Lordosis: refers to the inward curvature of the spine as it occurs normally in the lumbar and cervical regions. It is secondary because it develops later after birth. Cervical lordosis is a result of head raise in infancy and lumbar lordosis is a result of walking.

The spine is composed of Bones, vertebrae that protect the spinal cord and support the body.

# 1- Cervical spine anatomy

- **C1 (atlas):** it has anterior and posterior arches and no vertebral body (Ring-like.) Articulates with the occipital condyles of the skull superiorly through the superior articulating process, in which 50% of flexion and extension of the head happens.
- **C2 (axis):** it has an anterior projection called odontoid process (or Dens) which is a significant stabilizer between C1 and C2. Note that C1 and C2 are held together by the transverse alar ligament. This anatomy is responsible for 50% of neck rotation.
- **Sub-axial vertebrae (C3-C7):** All are similar in shape and structure and have two lateral facet joints.

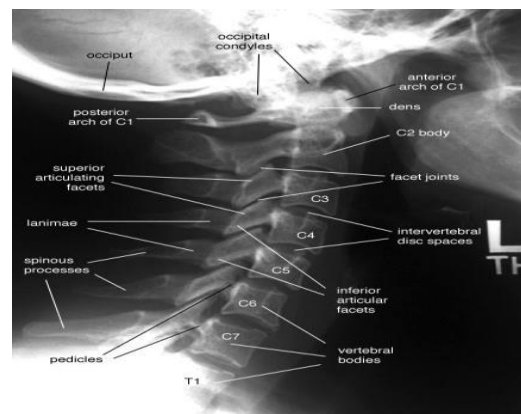
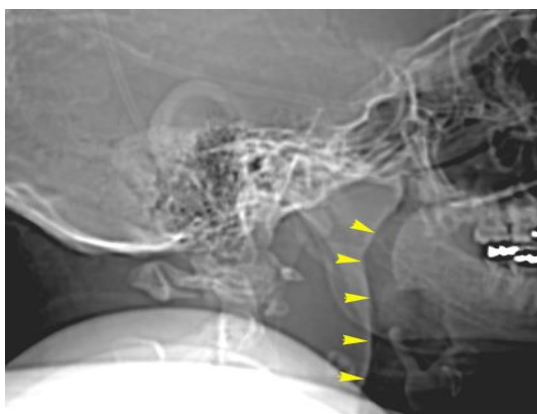


## Radiological Anatomy of cervical spine

### In Lateral View

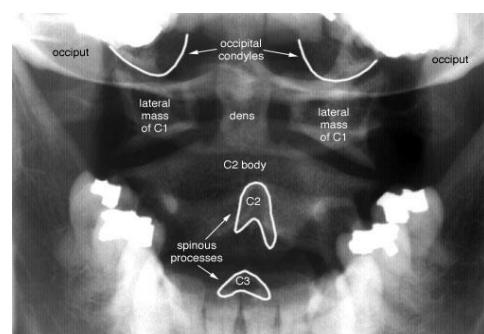
An adequate C-spine X-ray image has to have:

- The upper border of T1.
- Observe all vertebrae for abnormality.
- Observe the alignment in three lines: **anterior body line, posterior body line, and spino-laminar line.**
- Observe soft tissue anterior to the vertebral bodies.



### In AP view

**(MCQ)** In order to see both C1 and C2 and their articulation (including the odontoid/dens), **an open-mouth X-ray is required.** (Also known as odontoid view) →

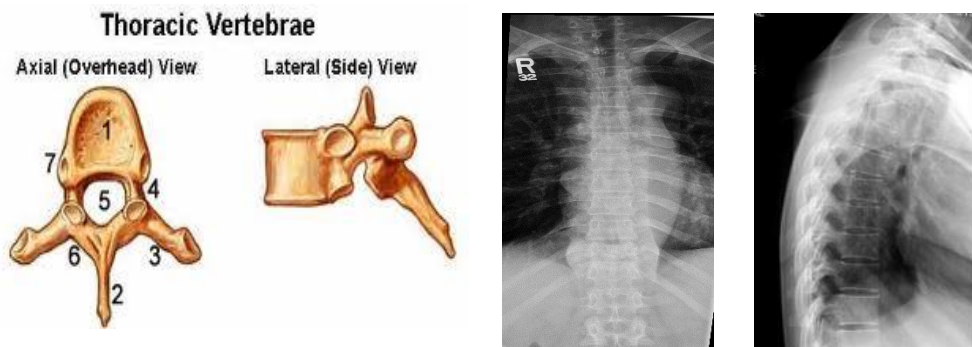




## 2- Thoracic spine anatomy

The vertebrae articulate with the ribs, the rib cage makes the thoracic spine stiffer than cervical and lumbar spines, which are very mobile. If injury happens, it tends to be between the stiff and mobile area (thoracic and lumbar).

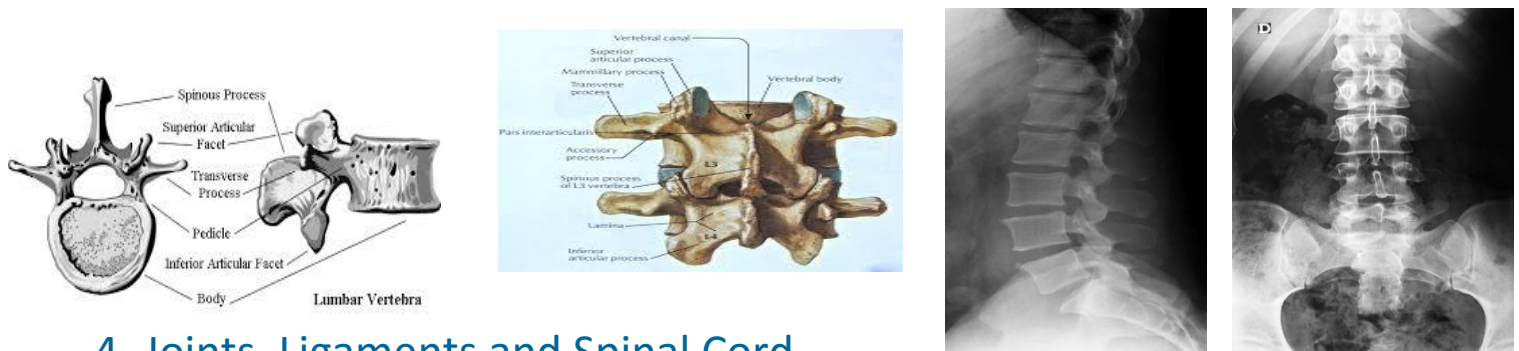
It is rarely injured; when an injury happens, suspect high energy trauma.



**Pic 1:** 1(vertebral body), 2(spinous process), 3(Transverse process), 4(Pedicle), 5(Spinal canal), 6(Lamina), 7(Facet)

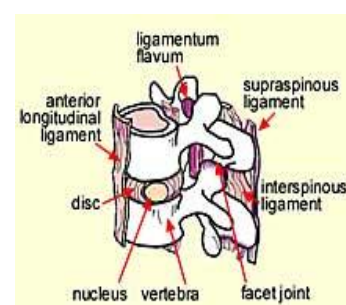
## 3- Lumbar spine anatomy

An important region. The facets are in sagittal plane, so it's where flexion and extension happen. Also, the most common region for fractures and disc herniation.



## 4- Joints, Ligaments and Spinal Cord

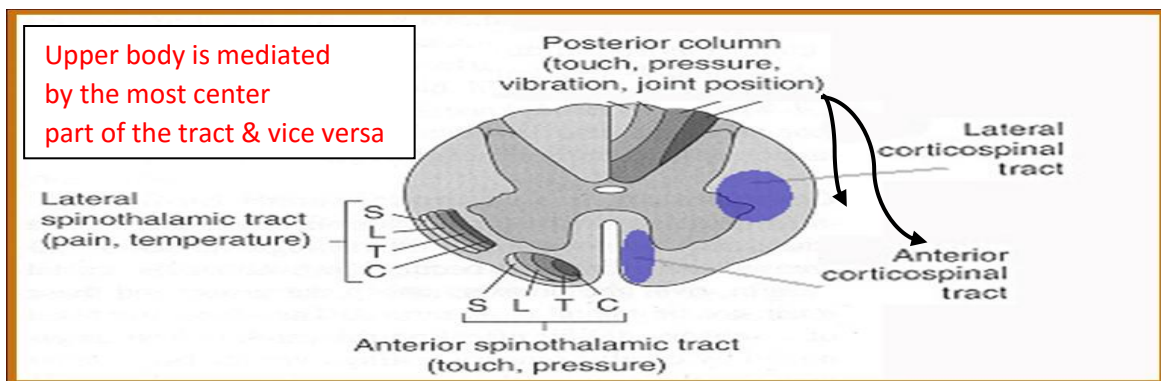
- Three joints in the spine: One anteriorly, **Inter-vertebral disc** which helps absorb pressure and keeps the bones from rubbing, and **two posteriorly**, 2 facet joints, one on each side.
- Movement of the spine: **Flexion, Extension, Lateral bending, Rotation.**
- Ligaments: **Supraspinous ligament, Interspinous ligament, Ligamentum flavum** (the least important in terms of stabilization), **anterior longitudinal ligament** and **posterior longitudinal ligament.**
- Ligament injury doesn't appear on X-ray (**will look normal**).



#Spinal Cord, in the spinal cord, all nerves related to the upper body occupy the tracts that are in the center of the cord, whereas the lower body occupies the peripheral region of the tracts. (Look at the Pic below)

**The most important tracts are:**

- 1/**Spinothalamic tract:** pain and temperature. (Ascending; fibers decussate at the level of their entry to the spinal cord).
- 2/**Posterior column:** touch, pressure, vibration and proprioception. (Ascending; fibers decussate within the medulla oblongata).
- 3/**Corticospinal tract:** motor fibers. (Descending; within the medulla, fibers of the lateral corticospinal tract decussate, and anterior tract remains ipsilateral).

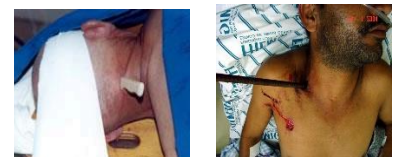


## Spinal Injuries

### Epidemiology

- 56000 cases per year, 11000 new spinal cord injuries.
- 15-20% multiple non-contiguous levels (in a comatose patient, radiological assessment of the whole spine is important when you can't examine the spine clinically).
- 10% involving the cervical spine, 90% involving thoracolumbar spine.
- 25% have neurologic deficit.
- Age: mostly between 15-24 years and mostly males (4:1).

### Mechanism



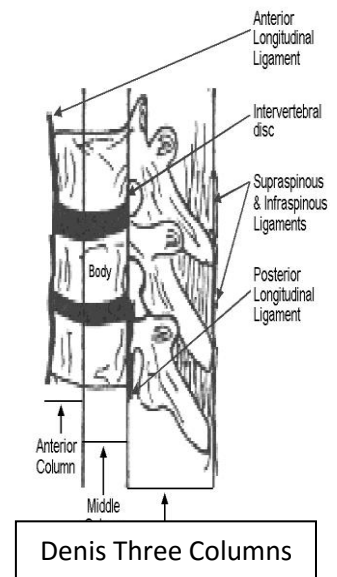
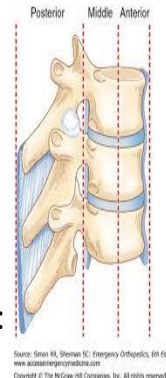
High Energy Trauma	Low Energy Trauma	Penetrating Trauma
E.g. MVA (Motor vehicle accident) or fall from a height or a horse. - MVA: 40-55% - Falls: 20-30% - Sports: 6-12% (Thoracolumbar injury) - Others: 12-21%	E.g. in a patient with known spinal canal compromise such as ankylosing spondylitis, Osteoporosis or metastatic vertebral lesions	from gunshot or knives

## Spine Stability (How to judge whether the injured spine is stable or not?)

### 1- Cervical Spine

a cervical spine injury is considered unstable if any of these is present:

- Compression fracture with **25%** loss of height.
- Angular displacement **> 11 degrees**.
- Translation **> 3.5mm**.
- Disc space separation **>1.7mm**.



### 2- Thoracic and lumbar spine

Stability is determined by **(Denis 3 Columns)** method:

- Anterior column on (Ant. part of vertebral body).
- Middle column on (Post. part of vertebral body).
- Posterior column on (Pedicle + Lamina + spinal process).

**Instability exists with disruption of any two of three columns.**

**Stable Injuries** —————> **Treated conservatively**

**Unstable Injuries** —————> **Treated Surgically**

## Assessment of Spinal Injury

<b>First Assessment</b>	<ul style="list-style-type: none"> <li>- In cases of trauma, <b>ABCDE's</b> must be assessed first and treated appropriately.</li> <li>- Patients should be examined with <b>cervical collar</b> until spinal pathology is excluded.</li> <li>- Careful <b>log rolling</b> keeping the head, neck and pelvis in line should be done to examine the spine properly.</li> <li>- <b>Immobilization</b> (by cervical collar, during transportation only; Temporary method) However, patient's position have to be changed periodically to prevent pressure sores development.</li> </ul>
<b>History</b>	<p>Ask About:</p> <ul style="list-style-type: none"> <li>- <b>Mechanism of injury</b>: Compression, flexion, extension, distraction, high or low energy injury ... etc.</li> <li>- <b>Other injuries</b></li> <li>- <b>Seat belt</b></li> <li>- <b>Other causalities</b> (presence of other passengers and their clinical situation. E.g. death at the scene indicates a possible high energy trauma).</li> </ul>
<b>Examination</b>	<ul style="list-style-type: none"> <li>- <b>Inspection</b></li> <li>- <b>palpation</b></li> <li>- <b>Neurologic examination:</b></li> <li>1/Muscle Test</li> <li>2/Sensory exam: light touch, Sharp dull discrimination, Vibration sense, Proprioception and two-point discrimination.</li> <li>3/Reflexes</li> </ul>



Left pic shows soft collar which is used only for muscles, left two are hard collar that is used in spinal injuries

## Signs of Spinal Trauma

During assessment, make sure if the patient have one or more of these as a sign of spinal injury:

1. Apnea, lower cranial nerve injury VIII-XII (high C-spine) which affect roots of phrenic nerve.
2. Deformity of the spine or neck.
3. Tenderness on palpation along spinal processes.
4. Paralysis or muscle weakness (which spinal level).
5. Loss of sensation (dermatomal distribution)
6. Loss of rectal tone.
7. Positive Babinski sign.

## Asia Score: Brief Trauma Neurologic Survey

Patient Name \_\_\_\_\_  
 Examiner Name \_\_\_\_\_ Date/Time of Exam \_\_\_\_\_

**ASIA** STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY **ISC**

**MOTOR**  
 KEY MUSCLES (according to reverse side)

C5	R	L	Elbow flexors
C6	R	L	Wrist extensors
C7	R	L	Elbow extensors
C8	R	L	Finger flexors (distal phalanx of middle finger)
T1	R	L	Finger abductors (middle finger)

UPPER LIMB TOTAL (MAXIMUM) (25) (25) (50)

Comments: \_\_\_\_\_

**LOWER LIMB**  
 KEY MUSCLES (according to reverse side)

L2	R	L	Hip flexors
L3	R	L	Knee extensors
L4	R	L	Ankle dorsiflexors
L5	R	L	Long toe extensors
S1	R	L	Ankle plantar flexors

Voluntary anal contraction (Yes/No)  S4-5

LOWER LIMB TOTAL (MAXIMUM) (20) (20) (40)

**SENSORY**  
 KEY SENSORY POINTS

Light Touch Score (max: 112) and Pin Prick Score (max: 112) tables for C2-L5 and S1-S4.

Any anal sensation (Yes/No)

Any sensory level (Yes/No)

Key Sensory Points: C2, C3, C4, C5, C6, C7, C8, T1, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11, T12, L1, L2, L3, L4, L5, S1, S2, S3, S4.

NEUROLOGICAL LEVEL: The most caudal segment with normal function.

COMPLETE OR INCOMPLETE?

ASIA IMPAIRMENT SCALE:

ZONE OF PARTIAL PRESERVATION:

SENSORY MOTOR:

**ASIA IMPAIRMENT SCALE**

- A = Complete:** No motor or sensory function is preserved in the sacral segments S4-S5.
- B = Incomplete:** Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5.
- C = Incomplete:** Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3.
- D = Incomplete:** Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade of 3 or more.
- E = Normal:** motor and sensory function are normal

**CLINICAL SYNDROMES**

- Central Cord
- Brown-Sequard
- Anterior Cord
- Conus Medullaris
- Cauda Equina

This is a system of tests used to define and describe the extent and severity of a patient's spinal cord injury and help determine future rehabilitation and recovery needs. The patient's grade is based on how much sensation he or she can feel at multiple points on the body, as well as tests of motor function. **When the test is complete, the patient is graded as A or B or C or D or E (E is best prognosis when patient shows full normal neurological functions, while A is worst when patient shows total loss of neurological functions.)**

Indicators of poor prognosis: Shock, Inability to breath and grade-A injury.



## Severity of Neurological Deficit:

### 1- Complete Deficit:

- Flaccid paralysis below level of injury. (May involve diaphragm if injury above C5 “phrenic nerve roots are C2-C4” and may cause neurogenic shock if fracture above T6 “due to loss of sympathetic tone”) \*MCQ\*
- If a spinal injury is below T6, neurogenic shock is unlikely.

### 2- Incomplete Deficit:

- If there’s any sensation, or sacral sparing.
- **Syndromes:** (you should know the features of each syndrome):

#### • Central Cord Syndrome:

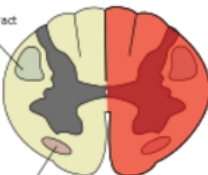
- Characterized by disproportion (**Upper Limb symptoms > Lower Limb**). In other words, worse neurological impairment in the upper limb.
- There’s sacral sparing
- Mechanism: **hyper-extension**
- Occur with or **without fractures**.
- Recovery: **50%** regaining function.
- Prognosis is fair.

#### • Anterior Cord Syndrome:

- Characterized by loss of corticospinal and spinothalamic tract with **preserved posterior column**. (Which mean loss of pain, temperature and motor function below the lesion, and preservation of deep touch, proprioception and vibration.)
- Mechanism: **ischemia** (reversible) or **infarction** (irreversible) to spinal cord.
- Common injury.
- Recovery: 10%.
- **sparing** after 24hrs portends a **poor outcome**.

#### • Brown-Sequard Syndrome:

- Characterized by **hemi-cord injury** with ipsilateral paralysis, loss of proprioception and light touch, and contralateral temperature and sharp pain loss. (Ipsilateral deficit of lateral corticospinal tract & dorsal column and contralateral lateral spinothalamic tract.)
- Prognosis is good, with over **90% regaining** of bowel and bladder function and ambulatory capacity.







- **Conus Medullaris Syndrome:**
    - Seen in T12-L1 injuries. (mixture of UMNL and LMNL)
    - Loss of voluntary bowel and bladder control with preserved lumbar root function.
    - Uncommon as pure lesion (mixed conus-cauda).
  - **Cauda Equina Syndrome:** (more details in the last slide)
    - **Saddle anesthesia, urinary retention and stool incontinence.**
    - Usually due to large central **disc herniation** rather than fracture.
- 3- **Nerve roots injuries** (lower motor neuron lesions).

### Complete Spinal Cord Injury

Complete loss of motor and sensory function below the spinal cord injury.




**Paraplegia**




**Tetraplegia**

### Incomplete Spinal Cord Injury

Partial or random preservation of motor or sensory function below the spinal cord injury.



**Paraplegia**

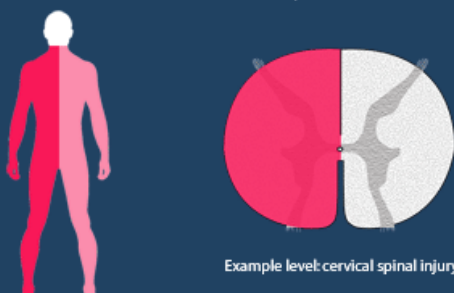


**Tetraplegia**

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### Common Types of Incomplete Spinal Cord Injuries

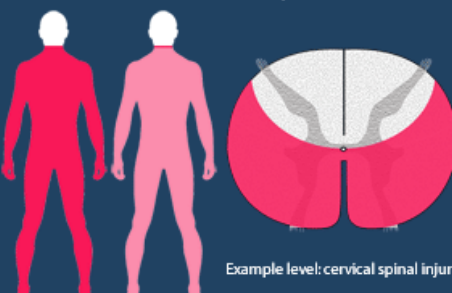
#### Brown-Séquard Syndrome



Example level: cervical spinal injury

Below injury level, motor weakness or paralysis on one side of the body (hemiparaplegia). Loss of sensation on the opposite side (hemianesthesia).

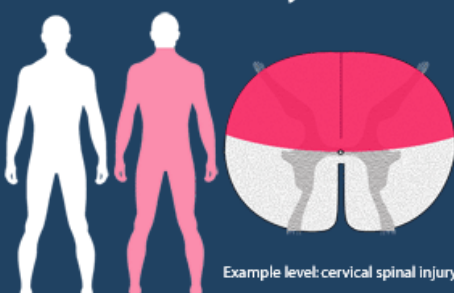
#### Anterior Cord Syndrome



Example level: cervical spinal injury

Below injury level, motor paralysis and loss of pain and temperature sensation. Proprioception (position sense), touch and vibratory sensation preserved.

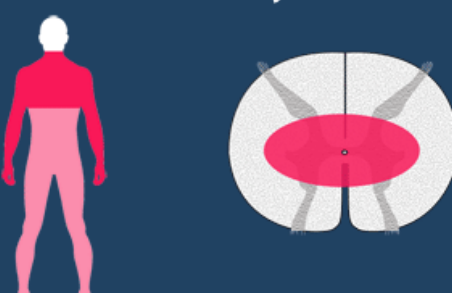
#### Posterior Cord Syndrome



Example level: cervical spinal injury

Below injury level, motor function preserved. Loss of sensory function: pressure, stretch, and proprioception (position sense).

#### Central Cord Syndrome



Results from cervical spinal injuries. Greater motor impairment in upper body compared to lower body. Variable sensory loss below the level of injury.

**Sources:** [www.apparelyzed.com](http://www.apparelyzed.com)  
[www.wikipedia.org](http://www.wikipedia.org)  
[sci.rutgers.edu](http://sci.rutgers.edu)

**Key:**

- Normal Function
- Impaired Motor Function
- Impaired Sensory Function

Revision the type of spinal cord injuries

## Shock:

### 1- Spinal Shock:

- Transient loss of spinal reflexes, Lasts 24-72 hours. (physiological shutdown of function)
- You can't tell if the spinal injury is complete or incomplete in the presence of spinal shock. **There's only one way to know that the shock has subsided: the presence of bulbo-cavernosus reflex.** If the reflex is present, spinal shock is over (it's the only reflex intact in complete spinal injury). To elicit bulbo-cavernosus reflex, squeeze the glans of penis in males or the clitoris in females and look for anal sphincter contractions.

### 2- Neurogenic Shock:

- Reduced tissue perfusion due to loss of sympathetic outflow and unopposed vagal tone, **so it is a cardiovascular phenomenon.** (Don't mix with spinal shock which is a neurological phenomenon)
- **Injury above T6 level.** Peripheral vasodilatation (hypotension and bradycardia).
- **Management: fluid resuscitation and vasopressors.** (When fluid resuscitation fails in a patient with neurogenic shock, do not repeat the initial bolus and **start vasopressors**)

## Imaging:

### 1- X-Ray:

- a) Cervical: 3 views: AP, Lateral and **open mouth** (to see C1-C2)
- b) Thoraco-lumbar: 2 views: AP & lateral, and Flexion-Extension view.

### 2- MRI: Best to evaluate **soft tissue.**

### 3- CT: Best for **bony** anatomy.

## Management of Spinal Injuries:

### Depends on:

- I. **Level** of injury.
- II. Degree and morphology of injury: **STABILITY**
- III. Presence of neurologic **deficit.**
- IV. Other factors.

## Some General Rules:

- 1- **Stable** injuries are usually treated **conservatively**.
- 2- **Unstable** injuries usually require **surgery**.
- 3- Neurologic **compression requires decompression**.

## Specific Injuries:

### 1- Cervical Spine Injury:

- Descriptive; depends on mechanism of injury:

- Flexion/extension,
- Compression/distraction.
- Shear.

- Presence of subluxation/dislocation

- SCI (spinal cord injury):

- **High level fracture results in quadriplegia.**

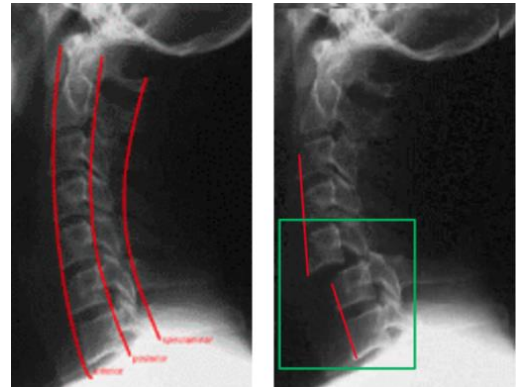
Generally speaking, cervical injury = quadriplegia.

- **Low level fracture results in paraplegia.**  
(C6 & C7 OR C7 & T1)

- **Soft tissue** swelling in cervical injury:

(just for your information)

- Nasopharyngeal space 10mm (adult)
- Retropharyngeal space 5-7mm
- Retrotracheal space 14mm (children),  
22mm (adults).



### 2- Thoraco-lumbar Injury:

- Spinal cord terminates at L1/2 disc in adult and L2/3 in a child.
- **50% of injuries occur at Thoraco-lumbar junction (most common site).**
- **Common fractures:**
  - a. Wedge fracture (flexion/compression) **“most common”**.
  - b. Burst (compression).
  - c. Chance (flexion/distraction).

### Wedge Fracture: “wedge means like a triangle”

- The distance between spinal processes is equal
- stable injury managed conservatively (pethidine and belt).

# In X-ray :

- AP view is normal
- Lateral view shows anterior column compressed only “so according to Denis 3 columns theory, it’s **stable**”

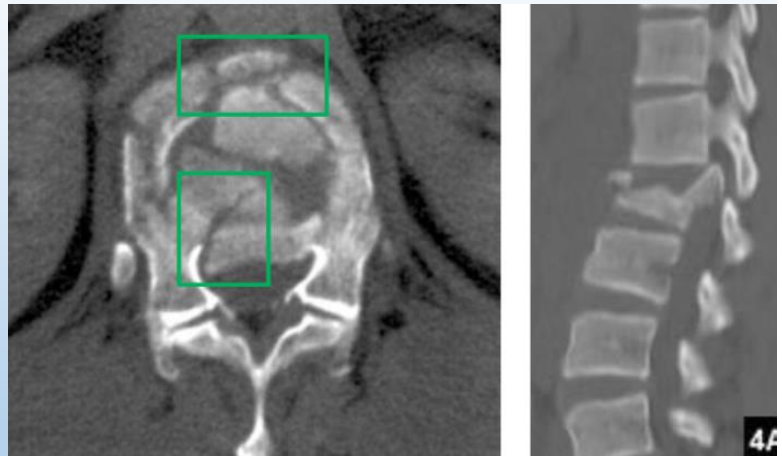


### Burst Fracture:

- Retro-avulsion traction, disturbed vertebral body, wide distance between pedicles.
- In the CT: there are fragments in the canal. Significant kyphosis.
- **Unstable fracture** managed surgically (compression or fixation) according to neurological deficit.

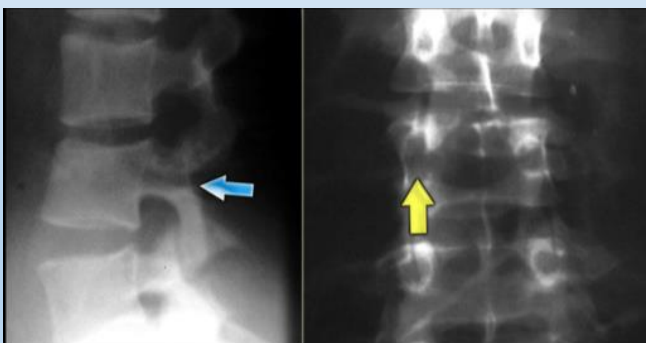
# In CT-Scan:

- Axial view: wide placed pedicles
- Saggital view: all 3 columns are affected = **Unstable**.



### Chance Fracture:

- Chance fracture could be: **bony chance or Ligamentous chance**.
- The spinal processes are not aligned and there is space between the pedicles.
- **Unstable fracture**, managed **surgically**
- Chance fracture could be caused by a seatbelt injury, mainly in children who wear the seatbelt without the chest piece. **40% is associated with intraabdominal injury**.



Bony Chance  
Flexion injury

Bony Chance  
Elongated Pedicle



Bony Chance – CT scan  
Hyper-flexion injury

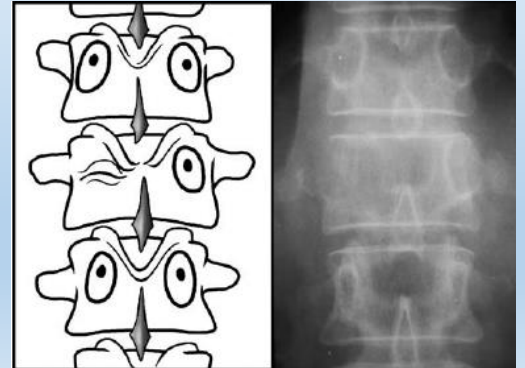


Ligamentous Chance



## Pathological Fracture:

- Low energy fracture (because bones are already diseased and weak, minor trauma may cause fracture)
- May be due to **osteoporosis** (common), or due to **tumor** or **infection** (appear in X-Ray as **“Winking Owl”** sign)
- (Winking owl sign is generally an indication of pathological lesion, with or without a fracture. It is formed of a missing pedicle. A winking owl sign + fracture = pathological fracture).



## Cauda Equina Syndrome:

- **A surgical emergency** (Common cause is disc herniation and spinal stenosis).
- Requires full neurologic examination **including rectal examination for anal tone and perianal sensation “MCQ”**.

### Clinical Features:

- **Motor (LMN signs):** Weakness and reduced deep tendon reflex (knee or ankle).
- **Autonomic:** Urinary retention and fecal incontinence due to loss of anal sphincter tone. (urinary retention at the beginning, but later when the bladder become full, overflow incontinence will happen)
- **Sensory:**
  1. Sciatica (low back pain radiating to thighs and legs).
  2. Bilateral sensory loss or pain depending on the level affected.
  3. Saddle anesthesia (S2-S5).
  4. Sexual dysfunction (late presentation).

### Investigations:

X-Ray initially, but **MRI is mandatory**, as X-rays are usually unremarkable.

## Treatment:

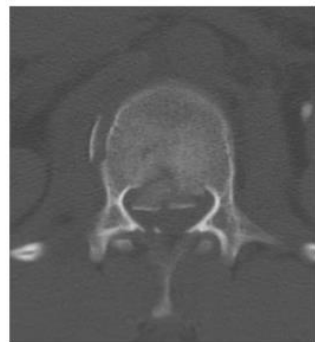
- **Emergency decompression**, usually **discectomy and wide laminectomy** within 24 hours.
- Prognosis is markedly improved with surgical decompression.

## Causes of cauda equine syndrome:

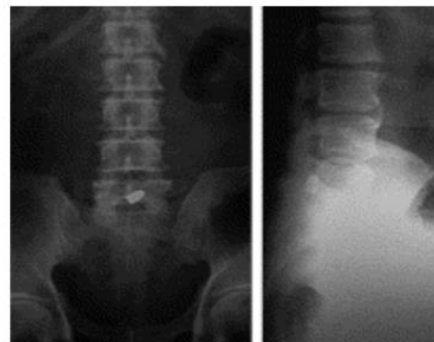
- Central disc prolapse.
- Burst fractures of lumbar spine.
- Penetrating injuries such as stab wounds or bullets.
- Epidural hematoma from spinal anesthesia, or post-surgery (rare).
- Tumors compressing the lower spinal nerve roots.
- Spinal Stenosis.



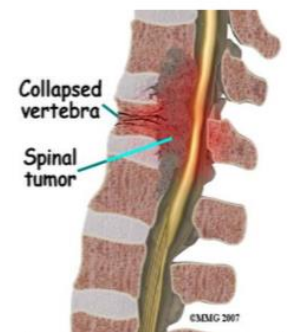
Disc hernia



Burst fracture



Bullet to cauda



Tumor

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