

**2024**

**Level 4 - Semester 7**



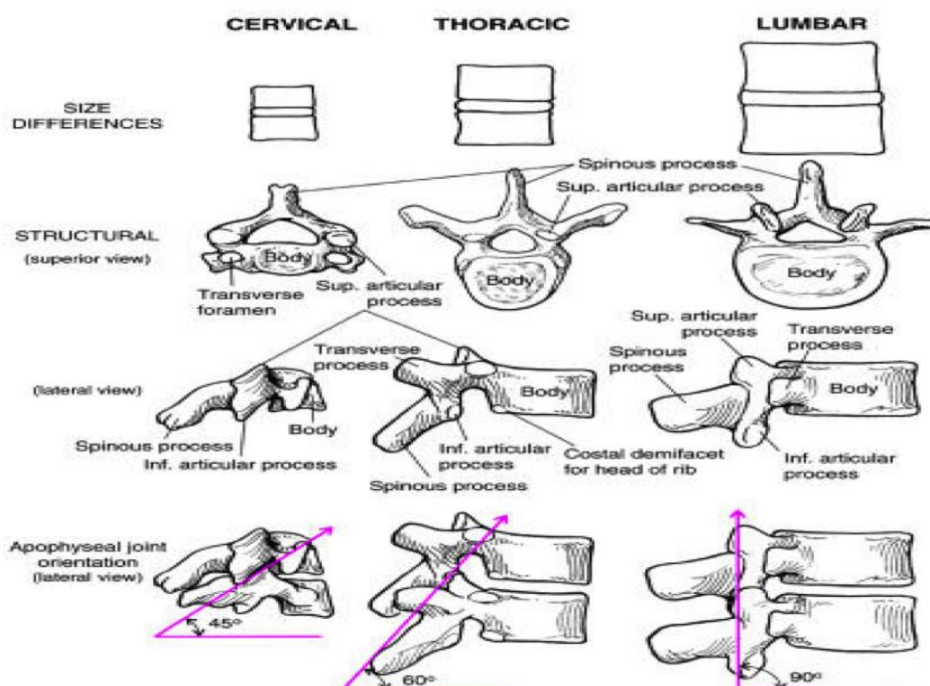
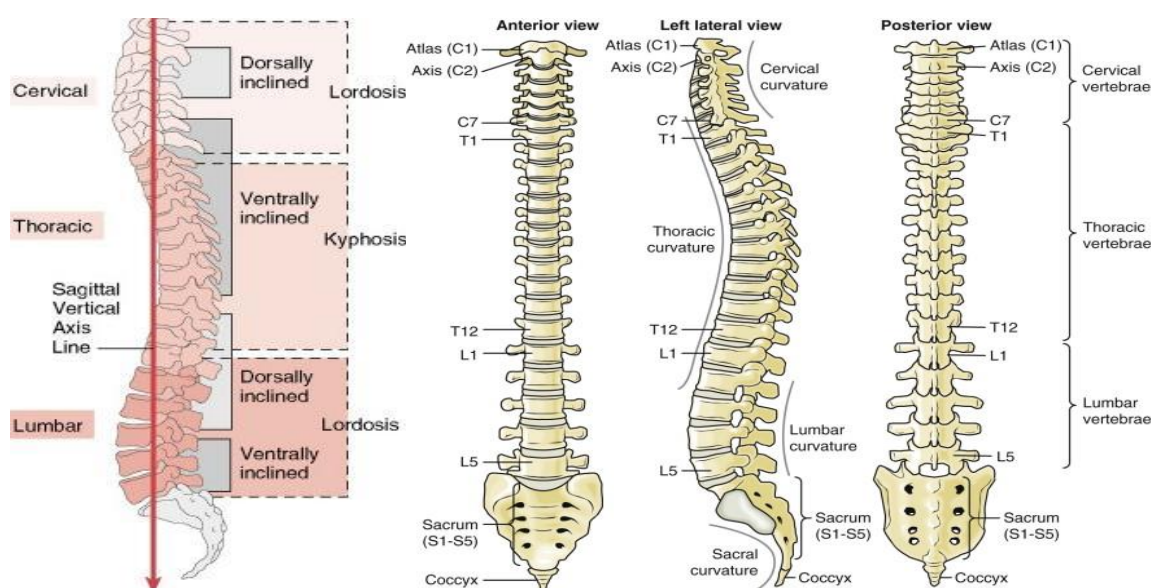
# **NEUROSURGERY**

## **SPINAL CORD INJURY**

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## SPINAL CORD ANATOMY

Cervical	<ul style="list-style-type: none"> <li>Small vertebral bodies (lesser weight bearing).</li> <li>Extensive joint surfaces allow <b>greater ROM</b> (rot, flex, ext.).</li> </ul>
Thoracic	<ul style="list-style-type: none"> <li>Rib bearing vertebrae.</li> <li>Designed to <b>remain stiff</b> (minimal flex, ext.).</li> </ul>
Lumbar	<ul style="list-style-type: none"> <li>Weight-bearing vertebrae, houses cauda equine (<b>min rot</b>).</li> </ul>
Sacral	<ul style="list-style-type: none"> <li>Transmits weight of body to the pelvis (<b>no motion</b>).</li> </ul>



## Spinal nerve roots pass out intervertebral foramen:

- C1-7 exit above.
- C8-L5 exit below.
- Spinal cord ends below lower border of L1

## Spinal nerve: ventral (motor), dorsal (sensor):

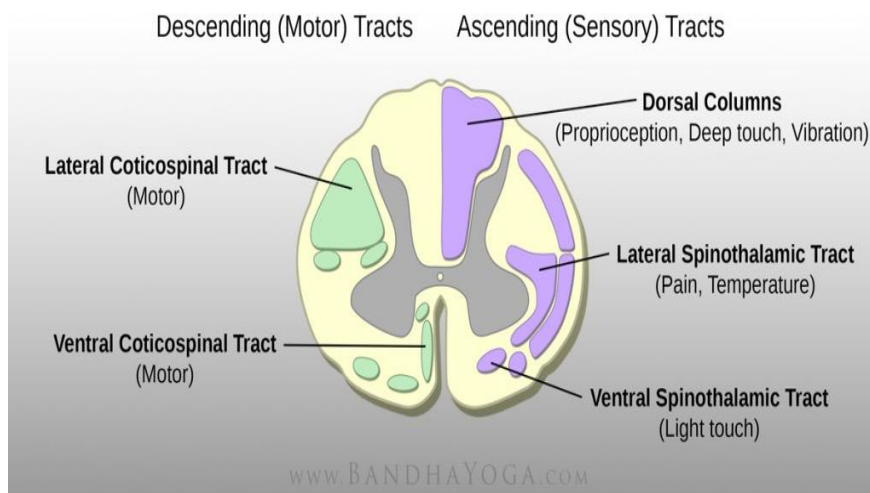
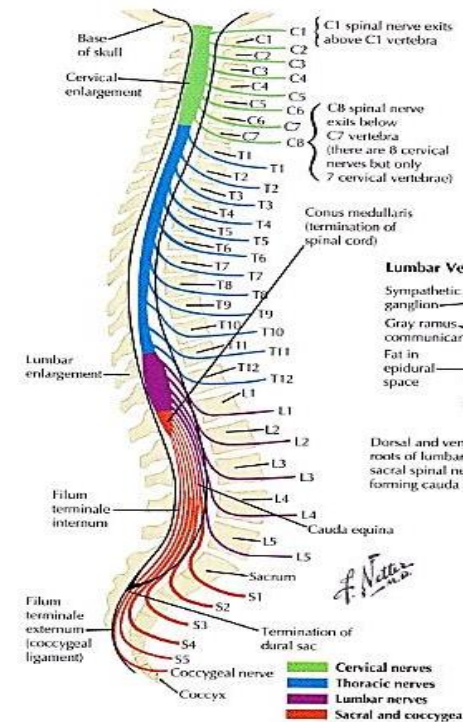
- Sensory cells in dorsal horn.
- Motor cells in Ventral horn.

## Cauda equina:

- Formed by L & S nerve in the spinal canal before exiting.
- Cauda equina is below L1.
- Neurological recovery **unpredictable** in cauda equina i.e., peripheral nerves.

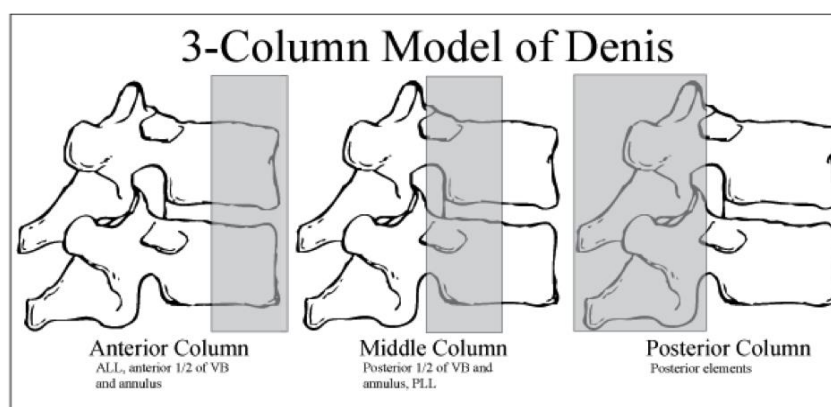
Mid dorsal spinal cord & neural canal space are of same diameter hence prone for **complete lesion**.

Mechanical injury-early ischemia, cord edema-cord necrosis.



## Spine anatomy

Anterior column	Anterior longitudinal ligament + Anterior annular ligament and anterior half of vertebral body.
Middle column	Posterior longitudinal ligament + Posterior annular ligament + Posterior half of vertebral body.
Posterior Column	Ligamentum flavum + superior and Interspinous ligament + intertransverse capsular ligament + neural arch + pedicle & spinous process.



## Significance

**Unstable fracture** if middle column + either anterior or Posterior column is damaged.

**Rupture of interspinous ligament:**

- Associated with **avulsion of spinous process**.
- Unstable spine**.
- Further **flexion increases neurological injury**.

## Cord level





T2 – T10 = add +2.

T11, T12, L1 =overlies the 11 lowest spinal segments.

# SPINAL TRAUMA







## Mechanisms of injury

Most important spinal cord injury indicator

Direct	 <b>Penetrating injuries to the spine</b> , particularly from firearms and knives.
Indirect	 <b>Most common cause of significant spinal damage.</b>  Fall from a height → spinal column collapses in vertical axis.  Forces: axial compression, flexion, lateral compression, flexion-rotation, shear, flexion-distraction, and extension.

## ♥ Common Mechanisms:

- 1) Compression (Flexion or Extension).
- 2) Distraction (Flexion or Extension).
- 3) Torsion.
- 4) Translation.
- 5) Penetration.

DESCRIPTION	DIAGRAM	EXAMPLES
<b>Hyperextension</b> Excessive posterior movement of head or neck		Face into windshield in MVC Elderly person falling to the floor Football tackler Dive into shallow water
<b>Hyperflexion</b> Excessive anterior movement of head onto chest		Rider thrown off of horse or motorcycle Dive into shallow water
<b>Compression</b> Weight of head or pelvis driven into stationary neck or torso		Dive into shallow water Fall of greater than 10 to 20 feet onto head or legs
<b>Rotation</b> Excessive rotation of the torso or head and neck, moving one side of the spinal column against the other		Rollover MVC Motorcycle accident
<b>Lateral Stress</b> Direct lateral force on spinal column, typically shearing one level of cord from another		"T-bone" MVC Fall
<b>Distraction</b> Excessive stretching of column and cord		Hanging Child inappropriately wearing shoulder belt around neck Snowmobile or motorcycle under rope or wire

## Types of spinal trauma

- 1) Cervical → 40%.
- 2) Thoracic → 10%.
- 3) Dorsolumbar → 35%.
- 4) Lumbar → 3%.
- 5) Any → 14%.



## DIAGNOSIS OF SPINAL CORD INJURIES (SCI)

### When to suspect spinal injury:

- 1) Sudden **decelerations** (MCA, falls).
- 2) **Compression injuries** (diving, falls onto feet/buttocks).
- 3) Significant **blunt trauma** (football, hockey, snowboarding, jet skis).
- 4) Very **violent mechanisms** (explosions).
- 5) **Unconscious** patient.
- 6) **Neurological** deficit.
- 7) Spinal **tenderness**.

### Clinical Evaluation

 **Document the level of injury.**

 **Rule out other injuries** → **Diagnostic peritoneal lavage (DPL)** in abdominal injuries as there is **paralytic ileus** and **absent peritoneal irritation**.




 **Associated injuries in dorsal spine fracture are:**

-  **Renal** injuries
-  **Retroperitoneal** injuries.
-  **Chest and Sternal** injuries.
-  **Wide Mediastinum** due to fracture hematoma.





### Level of Spinal injury:

 **Neurological level is at the lowest segment with normal motor & sensory function.**

 **Difficult to determine the level as:**

-  Most muscle efferents receive fibers from more than one level.
-  Closed cord lesions may extend over several cms.
-  Dermatomes have imprecise boundaries.

### Key Points:

-  Every patient with a **blunt injury above the clavicle**, a **head injury** or **loss of consciousness** is considered to have a **cervical spine injury** until proven otherwise.
-  Every patient who is involved in a **fall from a height** or a **high-speed deceleration accident** should similarly be considered to have a **thoracolumbar injury**.
-  Consider presence of a **vertebral column injury** in all patients with **multiple injuries**.
-  **Lesser injuries** also should arouse suspicion if they are **followed by pain in the neck or back** or **neurological symptoms in the limbs**.

## Clinical Examination

### Inspection and palpation: Occiput to Coccyx.

👤 Tenderness

👤 Edema and bruising

👤 Gap or Step

👤 Spasm of associated muscles

### Neurological assessment:

1) Sensation.

3) Rectal examination.

2) Motor function.

4) Reflexes.

## Sensory

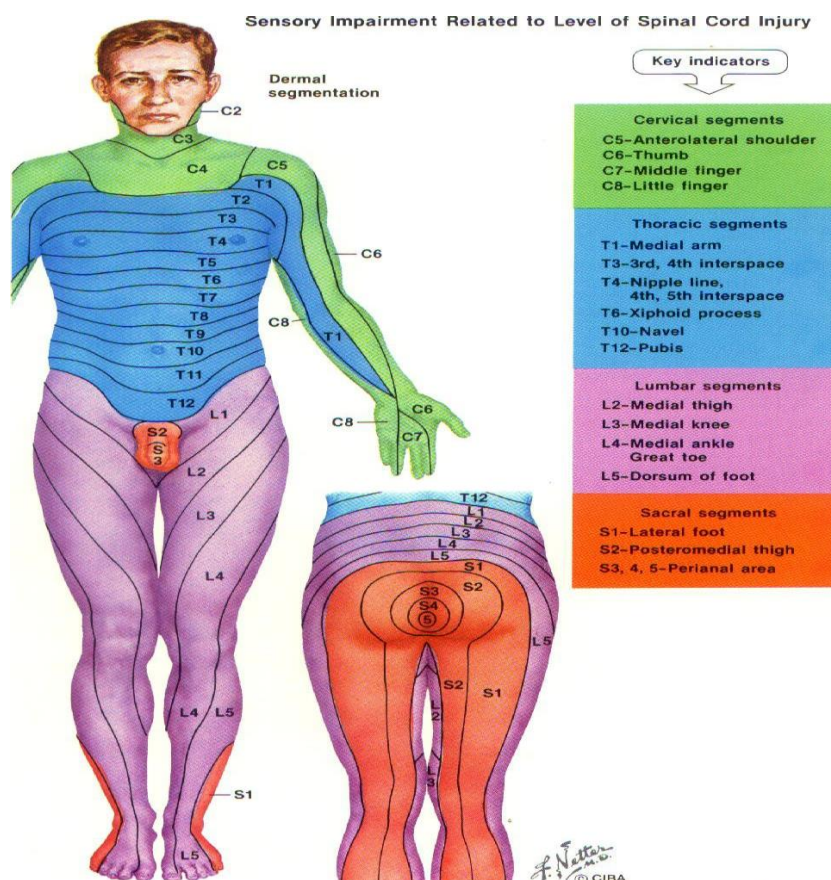
### 👤 Grading scale: 0-2.

👤 **0** → Absent.

👤 **1** → Impaired.

👤 **2** → Normal.

👤 **NT** → Not testable.







## Rectal

 **Tone:** Presence of rectal tone -in itself- does not indicate an incomplete injury








 **Sensation.**











 **Bulbocavernosus reflex:**

Center	S2-S4
Stimulus	Squeezing the glans penis or clitoris or tugging on an indwelling Foley catheter
Response	Anal sphincter contraction
Reflex absence	<p> The <b>absence</b> of the reflex in a person with acute paralysis from trauma indicates <b>spinal shock</b> whereas <b>the presence of the reflex</b> would indicate <b>spinal cord severance</b>.</p> <p> Absence of this reflex in instances where <b>spinal shock is not suspected</b> could <b>indicate a lesion or injury of the conus medullaris or sacral nerve roots</b>.</p>
Reflex Return	<p> Typically, this is <b>one of the first reflexes to return after spinal shock</b>.</p> <p> Lack of motor and sensory function after the reflex has returned indicates complete SCI.</p>

## Motor

 **Grading Scale: 0 - 5**

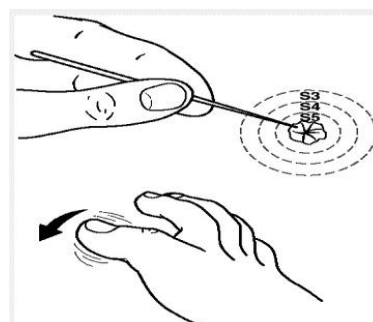
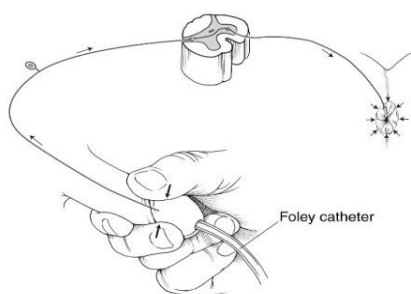
-  **0** → Total paralysis.
-  **1** → Palpable or visible contraction.
-  **2** → Active movement: **gravity eliminated**.
-  **3** → Active movement: **against gravity**.
-  **4** → Active movement: **against some resistance**.
-  **5** → Active movement: **against full resistance**.
-  **NT** → not testable.

Upper Limb	Lower Limb
 <b>C5:</b> Deltoids/biceps	 <b>L2:</b> Hip flexors
 <b>C6:</b> Wrist extensors	 <b>L3:</b> Knee extensors
 <b>C7:</b> Elbow extensors	 <b>L4:</b> Ankle dorsiflexors
 <b>C8:</b> Finger flexors	 <b>L5:</b> Long toe extensors
 <b>T1:</b> Finger Abductors	 <b>S1:</b> Ankle plantar flexors



## Sacral Sparing








Evaluating Sacral Sparing	<p>Perform a <b>rectal examination</b> to check motor function or sensation at <b>the anal mucocutaneous junction</b>.</p> <p>The presence of either is considered <b>sacral sparing</b>.</p>
Procedure	<p>May include assessment of <b>the triad of perianal sensation, rectal tone, and great toe flexion</b>.</p>



**Definitions of complete and incomplete SCI are based on ASIA definition with sacral sparing:**


Complete	Incomplete
<p><b>Absence of sensory and motor functions in the lowest sacral segments.</b></p>	<p><b>Preservation of sensory or motor function below the level of injury, including the lowest sacral segments.</b></p>

## Degrees of injury


Complete	 <b>Flaccid paralysis + total loss of sensory &amp; motor functions.</b>
Incomplete	 <b>Mixed loss:</b> <ul style="list-style-type: none"> <li> Anterior SC syndrome.</li> <li> Posterior SC syndrome.</li> <li> Central cord syndrome.</li> <li> Brown Sequard's syndrome.</li> <li> Cauda equina syndrome.</li> </ul>

### 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

### Common Types of Incomplete Spinal Cord Injuries

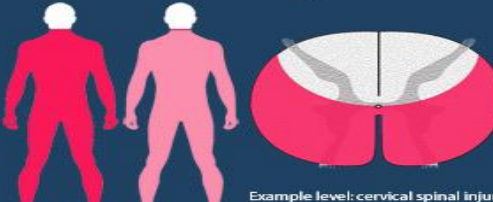
#### Brown-Séquard Syndrome



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

	Anterior cord syndrome	Posterior cord syndrome
Cause	 Flexion rotational force to spine.  Due to compression fracture of vertebral body or anterior dislocation.	Hyperextension injuries.
Pathology	Anterior spinal artery compression.	Posterior vertebral body fracture.
Symptoms	 Loss of power,  Reduced pain,  ↓ temp below the lesion.	 Loss of proprioception and vibration sense.  Severe ataxia.

	Central cord syndrome	Brown sequards syndrome
Cause	 Older age with cervical spondylosis.  Hyperextension with minor trauma.  Cord is compressed by osteophytes from vertebral body against thick ligamentum flavum.	Stab injury and lateral mass fractures.
Pathology	 Damages the central cervical tract.	Hemisection of the cord.
Symptoms	 UMN lesion to legs (spastic).  LMN to arms (flaccid paralysis).	 Uninjured side has good power but <b>absent pinprick and temperature.</b>  Spinothalamic tracts cross to opposite side of the cord three segments below.

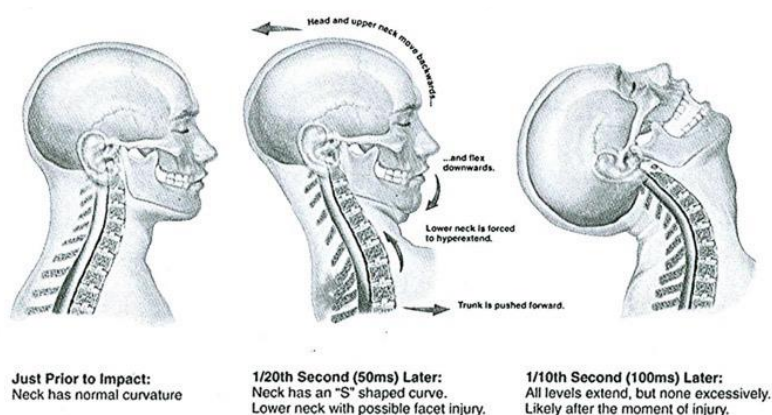
### Pathophysiology of Neurological damage

Primary damage	<b>Direct trauma, hematoma, and SCIWORA &lt; 8 yrs. old.</b>	
	<b>In 4hrs</b> - Infarction of <b>white matter</b> occurs.	
	<b>In 8hrs</b> - Infarction of <b>grey matter and irreversible paralysis.</b>	
Secondary damage	Hypoxia.	Hypoperfusion.
	<b>Neurogenic shock.</b>	<b>Spinal shock</b>

	Neurogenic shock	Spinal shock
Pathophysiology	<b>Hemodynamic instability</b> occurring with <b>rostral cord injuries</b> related to the <b>loss of sympathetic tone to the peripheral vasculature and heart</b> , leading to <b>bradycardia</b> , <b>hypotension</b> , and <b>hypothermia</b> . <b>Lesions above T6.</b> <b>Minutes–hours</b> (fall of catecholamines may take 24 hrs.)	Loss of sensation accompanied by motor paralysis with initial loss but gradual recovery of reflexes. <b>Transient physiological reflex depression of cord function</b> – ‘concussion of spinal cord’.
Symptoms	Disruption of sympathetic outflow from <b>T1-L2</b> . Unopposed <b>vagal</b> tone. <b>Peripheral vasodilation.</b> <b>Hypotension, bradycardia,</b> <b>Hypothermia</b> is caused by absent thermoregulation.	Loss anal tone, reflexes, autonomic control within 24-72 hr. <b>Flaccid paralysis</b> <b>Loss of bladder &amp; bowel control.</b> <b>Priapism.</b>
Recovery	--	<b>Lasts even days till reflex neural arcs below the level recovers.</b>
DD (add)	<b>Consider hemorrhagic shock if:</b> <ul style="list-style-type: none"> <li> Injury below T6,</li> <li> Other major injuries,</li> <li> Hypotension with spinal fracture only without neurological injury.</li> </ul>	--

## Whiplash injury

Cause	<p><b>Sudden hyperextension and flexion.</b></p>
Symptoms	<p><b>90% are asymptomatic after 2 years.</b></p> <p><b>Increasing neck pain for the first 24 hours.</b></p> <p>Associated headache, pain radiating to both shoulders and paresthesia in hands.</p> <p><b>Tear Anterior longitudinal ligaments → dysphagia.</b></p> <p>Forward flexion against resistance is painful.</p>



## RADIOLOGY

**Suspect the level from examination and mode of trauma.**

**Start with X-ray.**

**If suspicious, CT.**

**MRI Indications:**



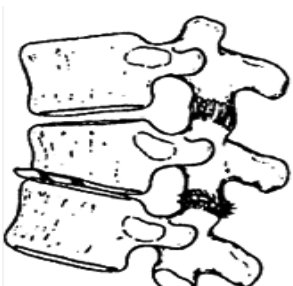

- Positive CT.
- high suspicion even with negative CT.
- Planning of surgery.



## BONY FRACTURE






### Compression Fracture

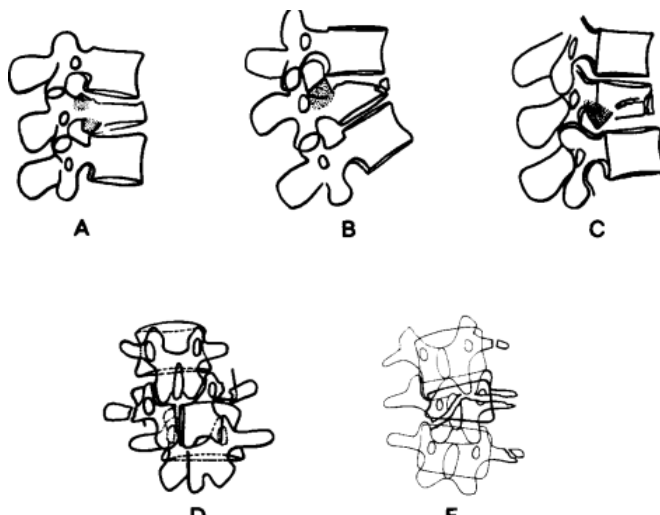
#### ♥ Subtypes of compression fractures:

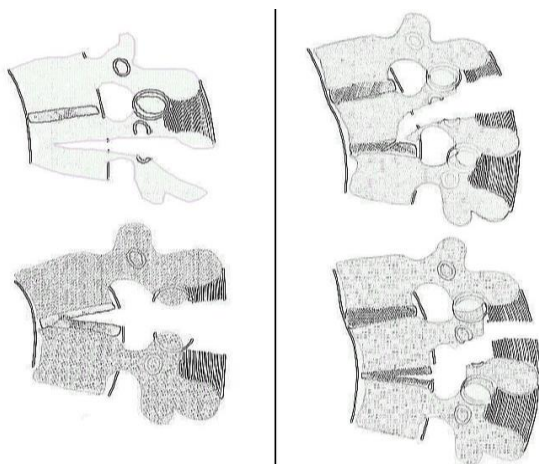
Type A	Type B
 <p>Fracture of both endplates</p> <p>Type A</p>	 <p>Fracture of superior endplate.</p> <p>Type B</p>
Type C	Type D
 <p>Fracture of inferior endplate</p> <p>Type C</p>	 <p>Both endplates intact.</p> <p>Type D</p>

### Burst Fracture

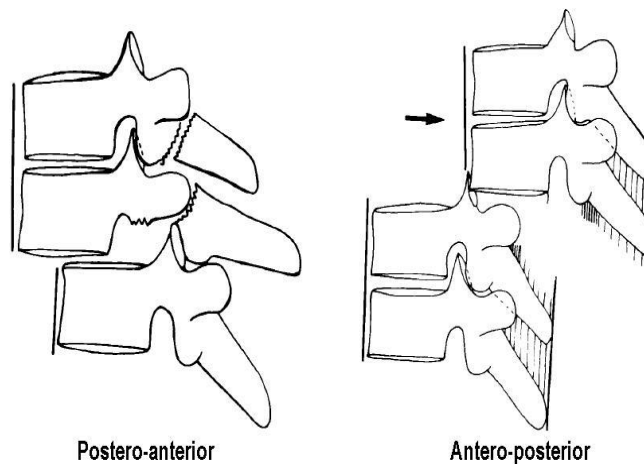
Compression fracture with disruption of endplate and the posterior cortex.

Type A	 Fracture of both endplates
Type B	 Fracture of superior endplate.
Type C	 Fracture of inferior endplate
Type D	 Burst rotation
Type E	 Burst lateral flexion

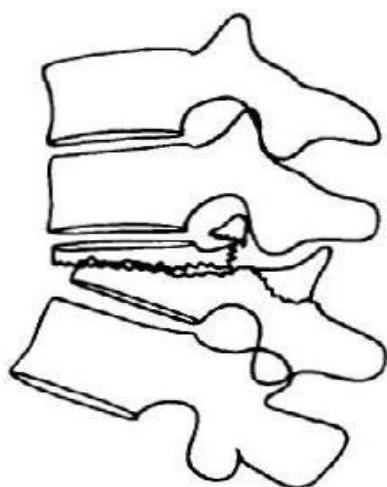




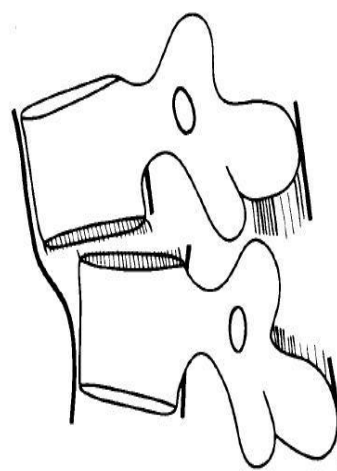
**Seatbelt-type Injury**



**Shear type**



**Flexion-Rotation type**



**Flexion-Distraction type**

## MANAGEMENT

### Emergency treatment

- 👤 **ABCDE.**
- 👤 **Keep warm.**
- 👤 **Treat if BP<80mmHg & HR <50 bpm.**
- 👤 **Spring loaded gardener wells calipers for traction.**
- 👤 **H2 Antagonists & Heparin.**
- 👤 **Methylprednisolone:**







Loading Dose	👤 30mg/kg iv bolus over 15 min immediately.
Maintenance	👤 5.4 mg/kg/h infusion over 23 hrs.

## Immobilization in hospital

**Priority → Protection.**

**Secondary → Detection.**

**Assisting devices:**

-  Rigid cervical collar
-  "Log-rolling"
-  Rigid transportation board (remove ASAP)
-  Rigid transfer slides






incorrect



Log roll  
(correct)



## Stable vs Unstable

Stable injuries	Unstable injuries
 Vertebral components will not be displaced by normal movements.  Little risk of neural damage	 There is a significant risk of displacement and consequent or further damage to the neural tissues
<b>Treat as unstable until proven otherwise</b>	

## Spinal instability

<i>Clinically</i>	 <b>The loss of the ability of the spine</b> -under physiologic loads- <b>to maintain relationships between vertebrae</b> in such a way that there is neither damage nor subsequent irritation to the spinal cord or nerve roots.
<i>Diagnosis</i>	 <b>Suspected from SLICS and TLICS score.</b>

### Spine Injury Classification and Severity score (SLICS)

3 Independent predictors

	Pathology	Score	Investigation / TTT
Morphology (Immediate Stability)	Compression	1	Radiographs CT
	Burst	2	
	Translation/rotation	3	
	Distraction	4	
Integrity of PLC (Long term Stability)	Intact	0	MRI
	Suspected	1	
	Injured	2	
Neurological status	Intact	0	Physical examination
	Nerve root	1	
	Complete cord	2	
	Incomplete cord	3	
	Incomplete cord injury with ongoing cord compression	4	
Predicts	Need for surgery. (By sum of parameters above)	0-3	Nonsurgical TTT
		4	Surgeon's choice
		> 5	Surgical TTT

### Thoraco-Lumbar Injury Classification and Severity score (TLICS)

3 Independent predictors

	Pathology	Score	Investigation / TTT
Morphology (Immediate Stability)	Compression	1	Radiographs CT
	Burst	2	
	Translation/rotation	3	
	Distraction	4	
Integrity of PLC (Long term Stability)	Intact	0	MRI
	Suspected	2	
	Injured	3	
Neurological status	Intact	0	Physical examination
	Nerve root	2	
	Complete cord	2	
	Incomplete cord	3	
	Cauda equina	3	
Predicts	Need for surgery (By sum of parameters above)	0-3	Nonsurgical TTT
		4	Surgeon's choice
		> 4	Surgical TTT



## SURGICAL MANAGEMENT

### Principles of definitive treatment

Treatment objectives	<ul style="list-style-type: none"> <li>To preserve neurological function.</li> <li>To minimize a perceived threat of neurological compression.</li> <li>To stabilize the spine.</li> <li>To rehabilitate the patient.</li> </ul>
Indications for urgent surgical stabilization	<ul style="list-style-type: none"> <li><b>An unstable fracture with progressive neurological deficit and/or MRI signs of likely further neurological deterioration</b></li> <li><b>Controversially an unstable fracture in a patient with multiple injuries</b></li> </ul>

### Acute management of spinal cord injury

#### Immobilization

#### ♥ Cervical:




- Patients with a known or suspected **cervical spine injury**, or those who are **comatose or intoxicated at the scene of injury**, should ideally be placed in a **cervical orthosis at the scene** (or **sandbags** if not available).
- Cervical traction is frequently applied using **Gardner-Wells tongs secured to the skull**.



#### ♥ Thoracolumbar:

- Most commonly, patients are **transported** to the hospital on a backboard.
- They should **not be allowed to sit or stand prior to evaluation**.
- During the physical examination, patients should be carefully logrolled by **multiple personnel for examination of the back**.

### Indications of surgical intervention

- 1) **Stabilization of fractures** is not likely to heal.
- 2) **Decompression of neural elements.**
- 3) **Early mobilization:**
  -  Some unstable spinal injuries may be potentially treatable with prolonged bed rest.
  -  Early surgical stabilization of the unstable spine may help to prevent prolonged bed rest complications; **atelectasis, pneumonia**, DVT, etc.
  -  It also allows the patient to begin rehabilitation earlier.

### Surgical Techniques



#### **Fusion.**



#### **Internal fixation (instrumentation).**



Internal fixation is not a substitute for fusion.



Screws, hooks, cages.



#### **Decompression of spinal canal (Laminectomy).**