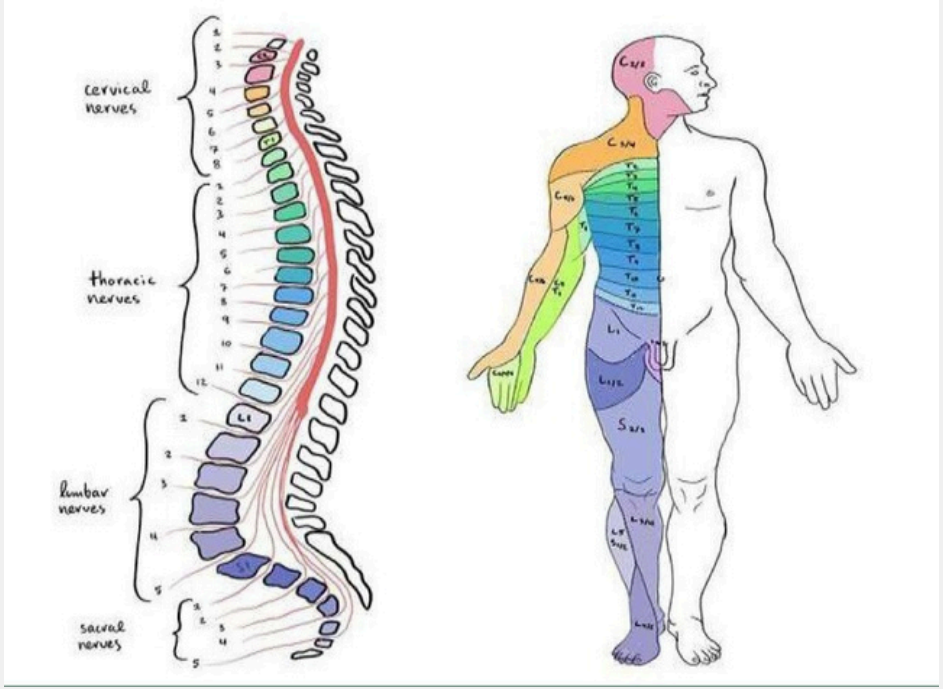
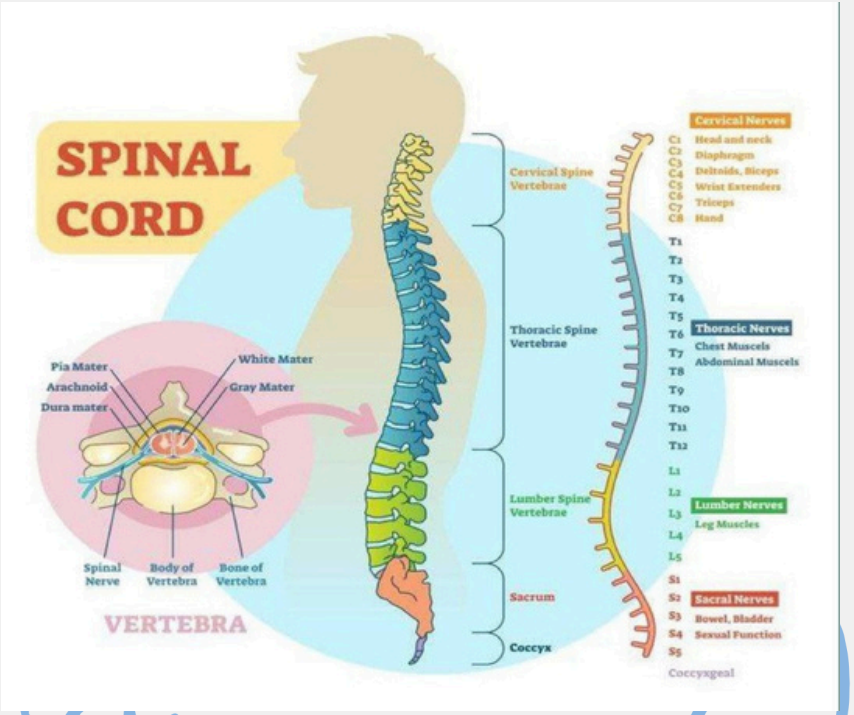
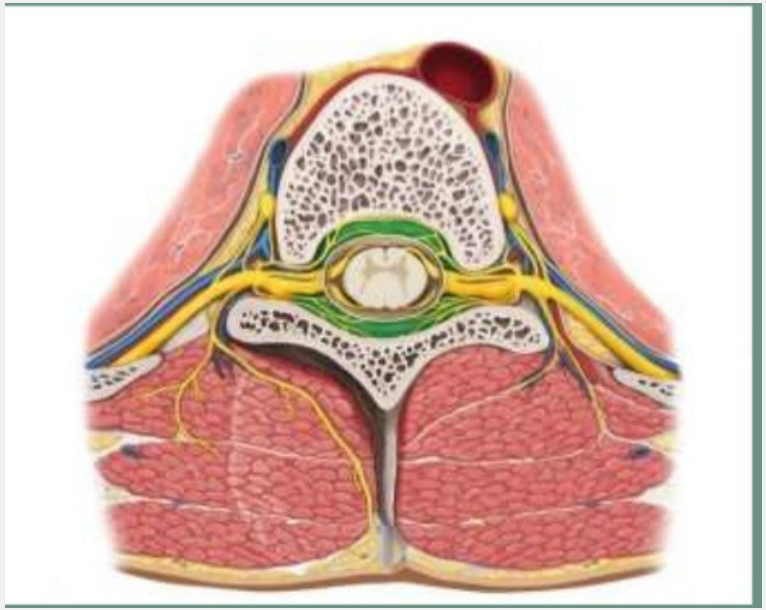
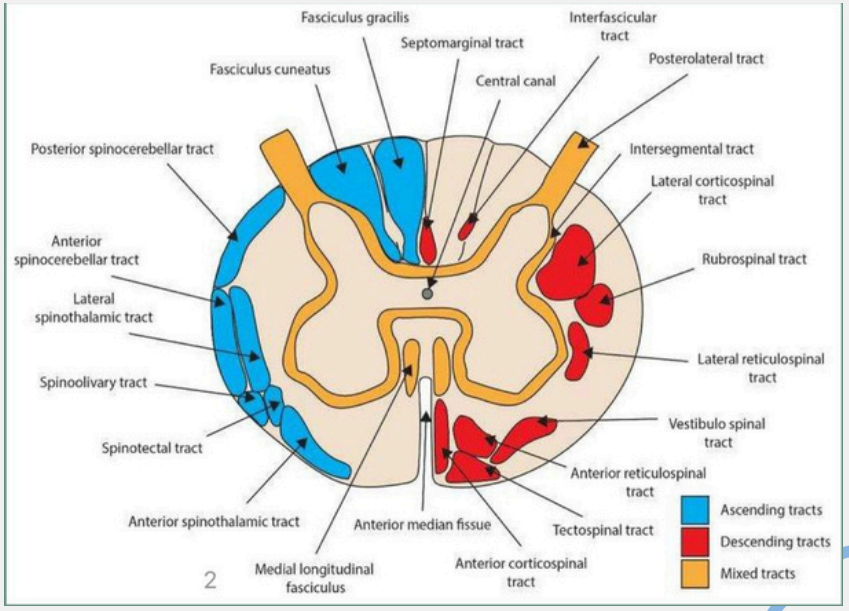
spinal cord injury





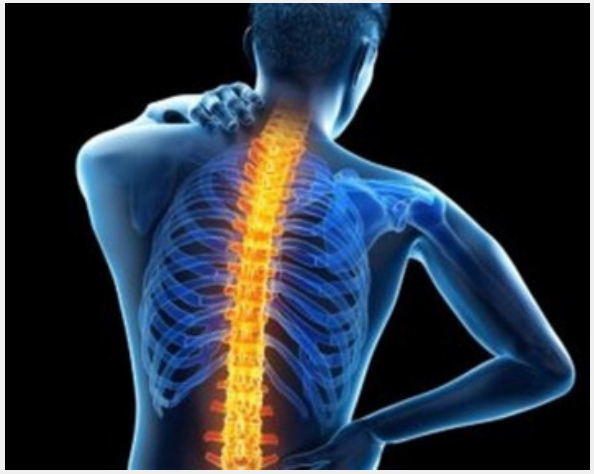
Normal anatomy and physiology





spinal cord injury

Spinal Cord Injury (SCI) is damage to the spinal cord that results in a loss of function such as mobility or feeling due to traumatic or non-traumatic causes.



epidemiology

-450,000 people live with SCI in USA.

->50% result in quadriplegia.

-10,000 new caselyear. -82% are males between 16-30 years. -45% are complete spinal damage.

-Co-morbidity Limb fractures

-67% Intrathoracic -53%

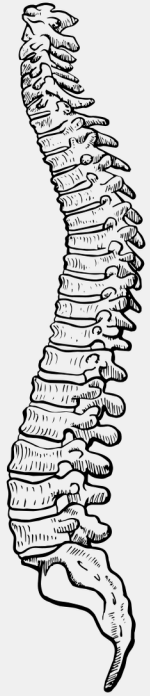
-50% involve the cervical spine c5-c6.

-Head injury -33%

Sign and symptoms

1-Weakness, numbness, tingling sensations or loss of feeling
2-Painful movements of arms and legs
3-Pain or tenderness along spine
4-Burning sensations along the spine or in an extremity
5-Deformity to patients head, neck or spine
6-Injuries to the head
7-Loss of bladder or bowel control
8-Labored breathing with little or no chest rise

causes



1.Traumatic SCI
(car accident, gunshot, falls, etc.)
2.Non-traumatic SCI
(polio, spina bifida, Friedreich's Ataxia, etc)

Traumatic sci

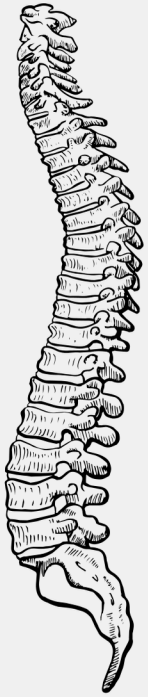
M echanisms

1-MVC 48%

2-Falls 21%

3-Assaults 15%

4-Sport-related 14% (majority diving)



Spinal and spinal cord injury

Spinal injury

- With or without cord injury

- Fractures

-Dislocation

- Facet lock

-Tx: reduction, fixation and fusion

Spinal cord injury

-With of without spinal injury

-Neuronal injury

- SCIW ORA

- Tx: decompression, then waiting spinal cord repair ???!!!

Tracts vs Nu

-When theres injury to a tracts it will effect all the levels below the injury level
-When theres injury to a Nu in the horns it will effect only at the level of the injury

Note:
The white matter increases in the spinal!
cord as you go
higher because the tracts keep adding up
till reaching the
destination.

Note:
The spinal cord does not have to be
severed in order for a loss of
functioning to occur.
SCI is very different from back injuries-
,such as ruptured disks
vertebral fractures or spinal stenosis.

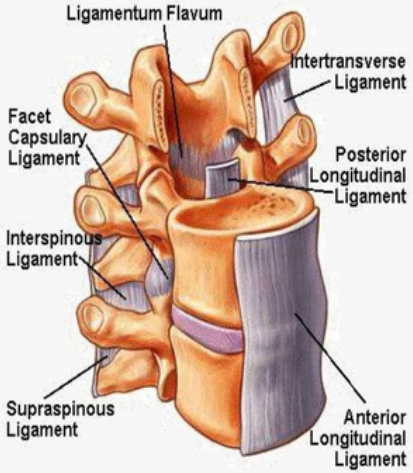
Spinal injury&Bony injury

!!!stablevsunstable fractures

-stable: not displaced by normal movements.

-unstable:significant risk of displacement and neural damage Neurological injuries is not always immediate and may occur or be aggravated only if there is a movement or displacement of vertebral fracture or dislocation (primary vs. secondary)

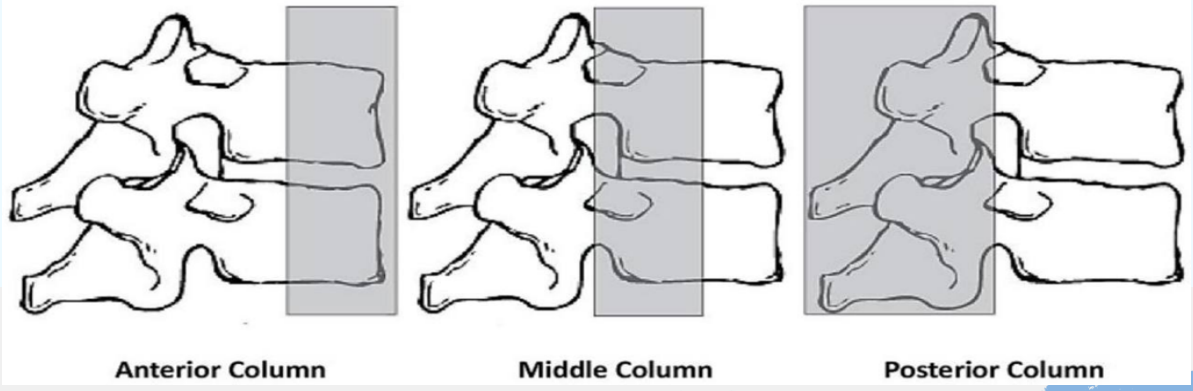
con....
So generally, it requires damage to both the ligaments and the bony column to produce unstable spine



DENIS Classification

~ A commonly used spinal injury classification system.

Used for thoracolumbar spine fractures
Based on the three-column model
Purpose: Helps identify spinal instability.
If 2 or more columns are disrupted → unstable fracture



Principles of diagnosis and management

-inappropriate movements during examination can change the outcometothe worse.

- immobilization is abandonedonly after serious spinal injuries has been excluded by clinicaland radiological assessment.

HISTORY:

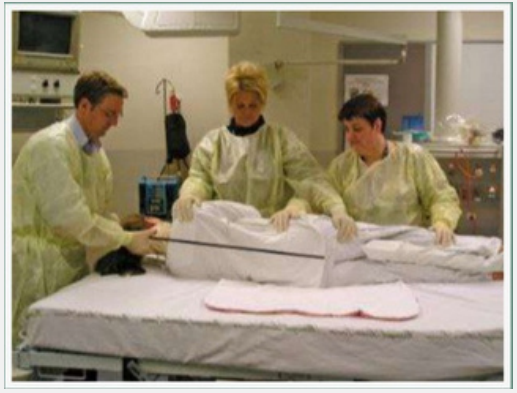
- High index of suspicion-signs and symptoms may be minimum.

-Every patient with blunt injury above the clavicle, head injury or loss of consciousness..

- Fall from height, crushing accident or high speed deceleration accident

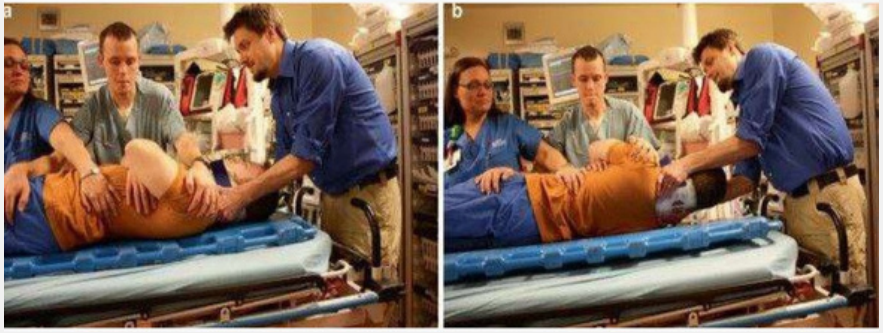
-Lesser injuries if followed by pain in the neck, back or neurological
.symptoms in the limbs

EXAMINATION (LOOK, FEEL BUT NOT MOVED)



-Inspect the head and the face for bruises.
-Exam the neck for deformity, bruising or penetrating injuries.
-The bones and soft tissues of the neck are palpated.
-Tenderness bogginess or abnormal space between adjacent spinous processes (suggest unstable spin).

Back:
-log-rolled-
-inspect and palpate the back



Full neurological examination:
-carried out and repeated several time during the first few .days
-Test each dermatome, myotome and reflex.

THE UNCONSCIOUS PATIENT:

Features suggesting spinal cord lesion:

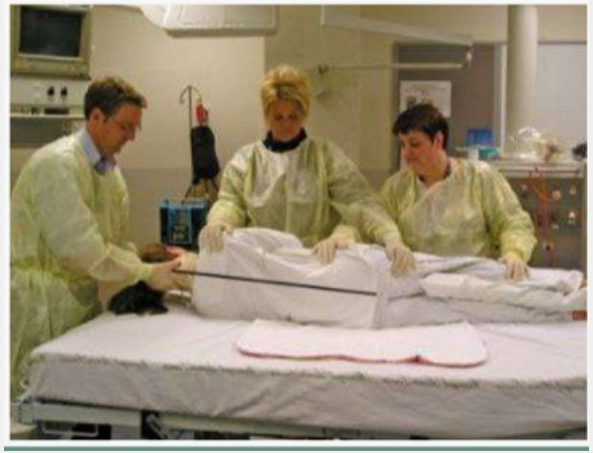
-Hx of fall or rapid deceleration.
- Head injury.
- Diaphragmatic breathing.
- Flaccid anal sphincter.
- Hypotension with bradycardia.
-Pain response above but not below the clavicles.

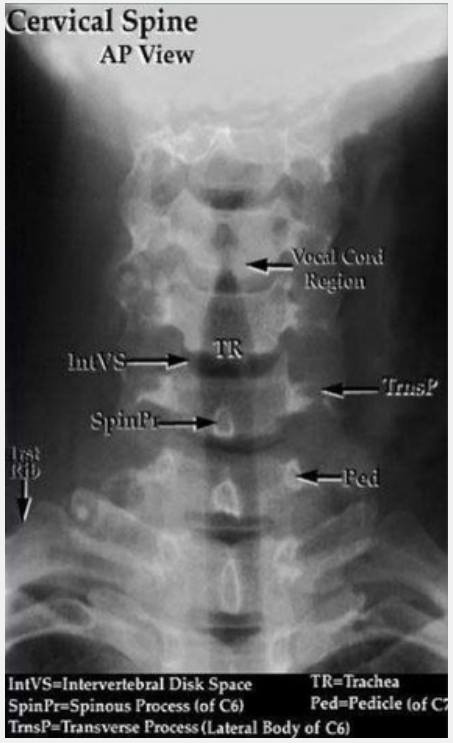
IMAGING

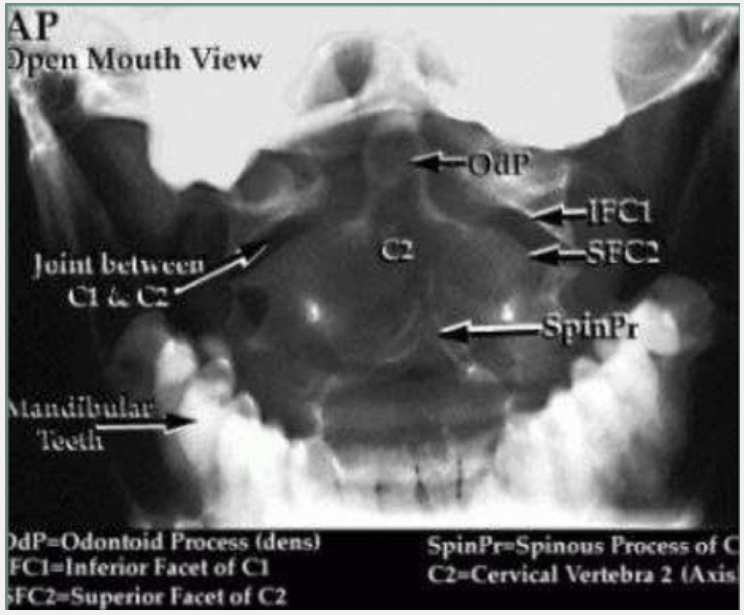
1-X-ray
Cervical spine: AP, lateral (c1 to t1) and open mouth.

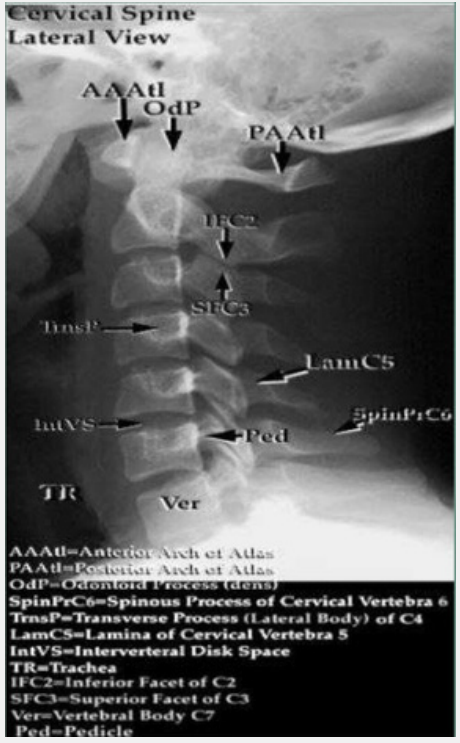
2-ct-Scan
for difficult area (lower cervical and upperthoracic), damage to individual vertebra and displacement of bone fragments.

3-MRI.
Intervertebral disc, lig flavum and neural structures




Cervical Spine
AP View
Vocal Cord Region
IntVS
TR
TrnsP
SpinPr
1st Rib
Ped
IntVS=Intervertebral Disk Space
SpinPr=Spinous Process (of C6)
TrnsP=Transverse Process (Lateral Body of C6)
TR=Trachea
Ped=Pedicle (of C

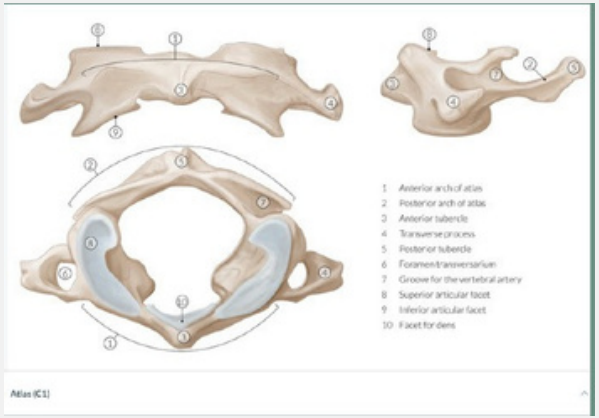

AP
Open Mouth View
OdP
IFC1
SFC2
C2
Joint between C1 & C2
SpinPr
Mandibular Teeth
OdP=Odontoid Process (dens)
IFC1=Inferior Facet of C1
SFC2=Superior Facet of C2
SpinPr=Spinous Process of C
C2=Cervical Vertebra 2 (Axis


Cervical Spine
Lateral View
AAAtl
OdP
PAAtl
IFC2
SFC3
TrnsP
LamC5
IntVS
SpinPrC6
Ped
TR
Ver
AAAtl=Anterior Arch of Atlas
PAAtl=Posterior Arch of Atlas
OdP=Odontoid Process (dens)
SpinPrC6=Spinous Process of Cervical Vertebra 6
TrnsP=Transverse Process (Lateral Body) of C4
LamCS=Lamina of Cervical Vertebra 5
IntVS=Interverteral Disk Space
TR=Trachea
IFC2=Inferior Facet of C2
SFC3=Superior Facet of C3
Ver=Vertebral Body C7
Ped=Pedicle

CERVICAL SPINE INJURIES

hx:
fall from height, diving accident, MVA in which the neck is forcibly moved
Examination:
abnormal position of the neck, tenderness, pain and parasthesia
imaging:
-AP view: the lateral outline should be intact, spinous process and tracheal shadow at the midline
-lateral view: from c1-to t1.

"FRACTURE OF C1. "JEFFERSON'S FRACTURE



- Result From sudden severe load from on the top of the head.
- Noencroachment of the neural canal, usually no neurological .damage

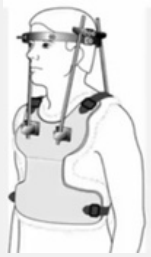
Gold stanard image of cervical spine in injured patient : CT

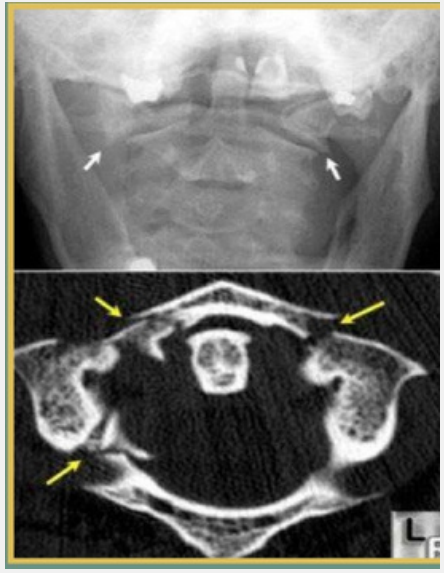
-Open mouth view x ray: spreading of the lat.masses away from the odontoid peg.

Treatment

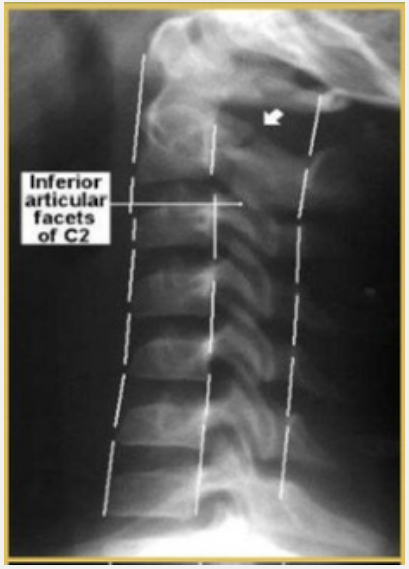
-stable, undisplaced fractures: rigid collar until the fractures unites

-unstable, sideway spreading of the lat.masses skull-traction, halo body orhtosis followed by semi rigid collar.



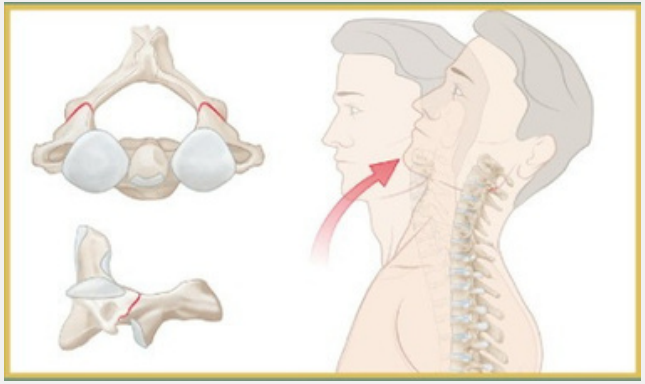


"FRACTURED PEDICLE OF C2 "HANGMAN'S



-bilateral fracture of the axis arch
-Fracture of C2 pars interartivularis with torn C2/C3 disc.
-Extension with distraction. MVA when the forehead strike the dashboard

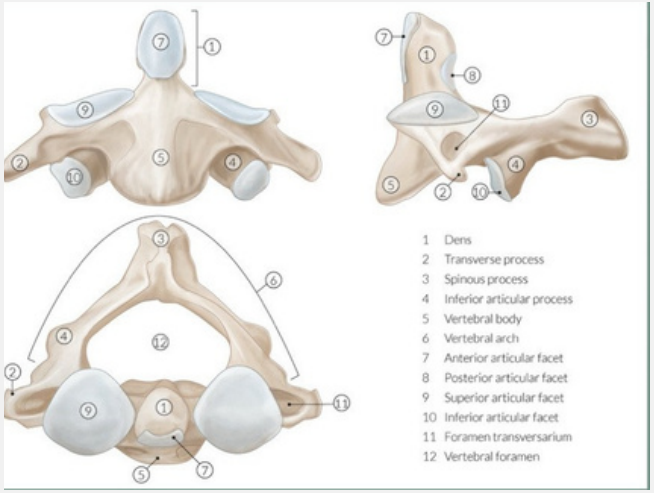
Treatment:
-Undisplaced fracture: semi rigid collar or halo-vast until united
-Displaced fracture: reduction then halo-vast for 12-weeks



FRACTURE OF THE ODONTOID PROCESS

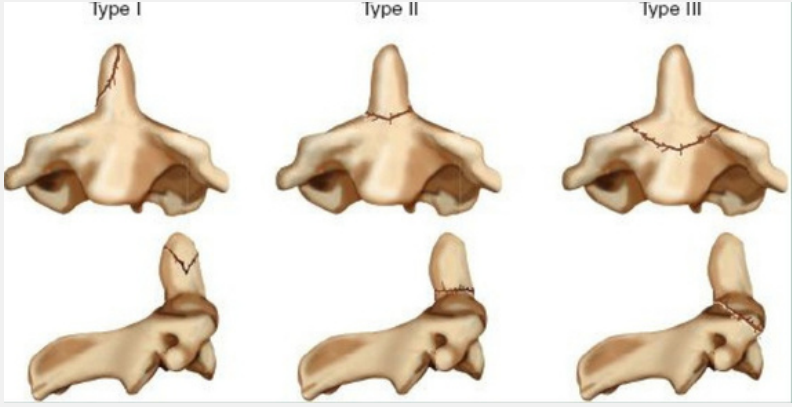
Flexion injury due to high velocity accident or falls.
-1/4neurological involvement.

• Neck pain with motion
• Dyspha can be present when associated with a large hematoma.



Type I: through tip of dens :
Its Avulsion fracture (attached to apical ligament)
Mostly managed conservatively by splintage **

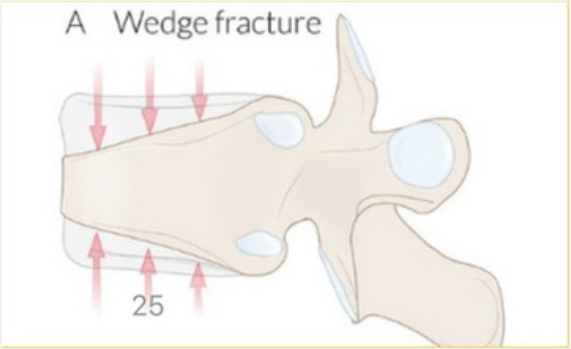
Type II: through base of dens :
It occurs in watershed area (there is decrease in blood supply)
so....
Common complications are :
1. AVN
2. Non union
Always managed by surgery ***



Type III: trough body of C2 :
Better healing than type 2 due to larger surface area
Management depends on :
Neurological deficit
Displacement
Occupation also may play role

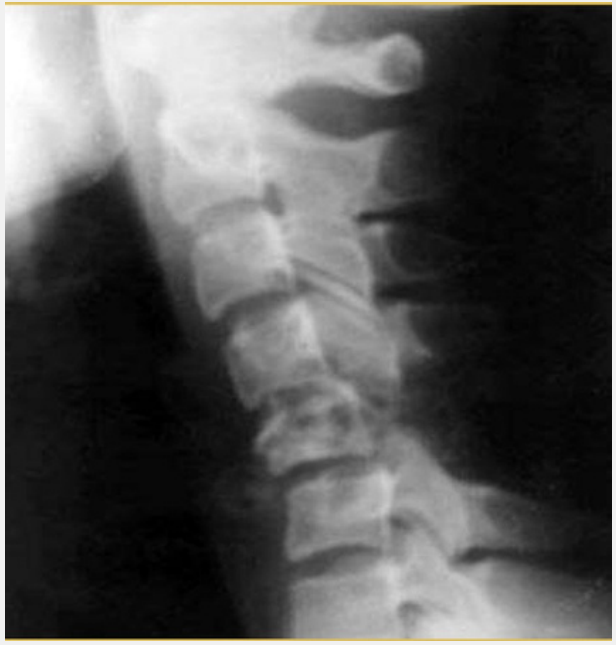
WEDGE-COMPRESSION FRACTURES

-Pure flexion injury



-characterized by a loss of height, predominantly of the anterior part of the vertebral body, which results in a wedge-shaped vertebra

-Stable injury, comfortable collar for 6-8 weeks

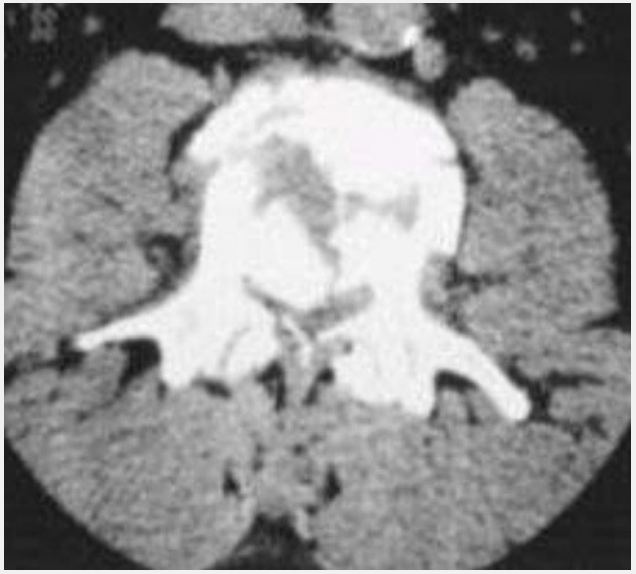


BURST FRACTURE

-Axial compression of the cervical spine. (usually in diving or athletic accident)
-persistent neurological injury is common.

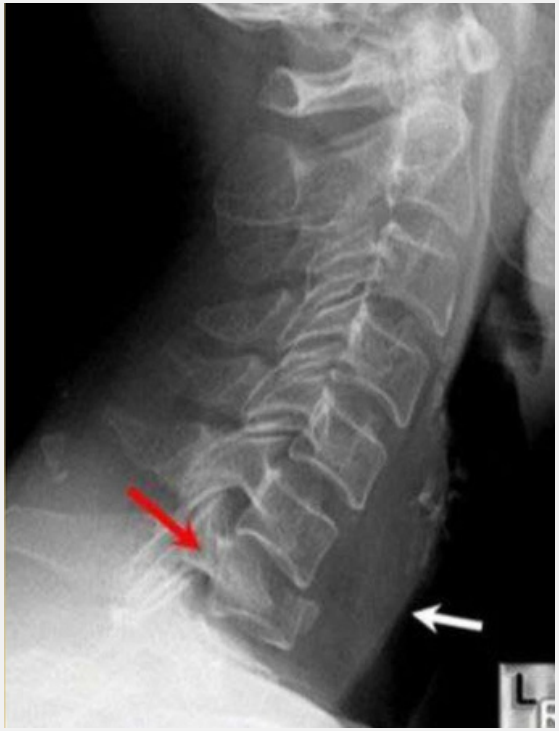
fracture of the vertebra in multiple locations
*Result of compression trauma with severe axial loading
*Possible displacement of bone fragments into the spinal canal

Treatment:
.Neurological deficit call for urgent ant
.decompression



BURST FRACTURE, C7

- Lateral view of the cervical spine demonstrates a comminuted vertical fracture through the body of C7. The posterior surface of C7 is displaced posterior toward the spinal canal (red arrow)while there is slight soft tissue swelling anteriorly (white (arrow



THORACIC SPINE IJURIES

-hyperflexion injuries.

-wedge compression fracture are relatively cmmon, mechanically stable but may lead to progressive kyphosis

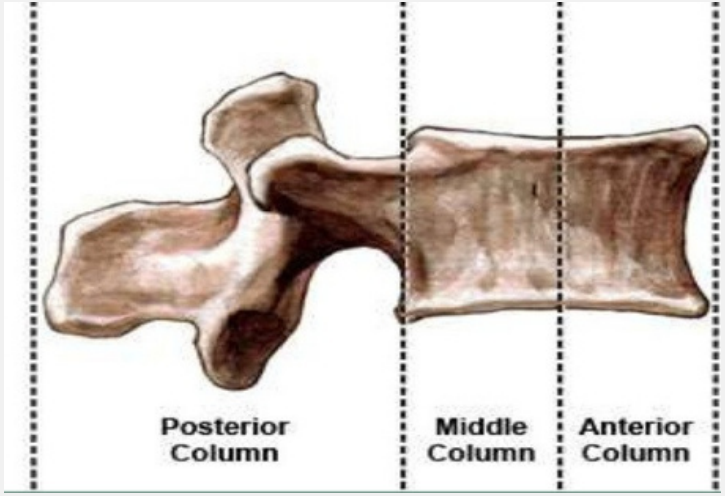
-t11-t12 carry high risk of cord damage.

THORACOLUMBAR AND LUMBAR INJURIES

Transtion zone between the relatively fixed thoracic spine and relatively mobile lumbar spine.

-stable vs. unstable
1.post.osteoligamentus complex (posterior column)
2.Middle column
3.ant.column

All fracture involving the middle column and at least one other should be regarded as unstable



• injuries to the spine may be complicated with spinal cord damage (burst fracture and fracture dislocation). which result in:

1.complete transection (paraplegia or quadriplegia).
2.incomplete transection (partial motor or sensory loss)

Complete SCI

-Loss of all functionbelow the level of the lesion

-Typically associatedwith spinal shock

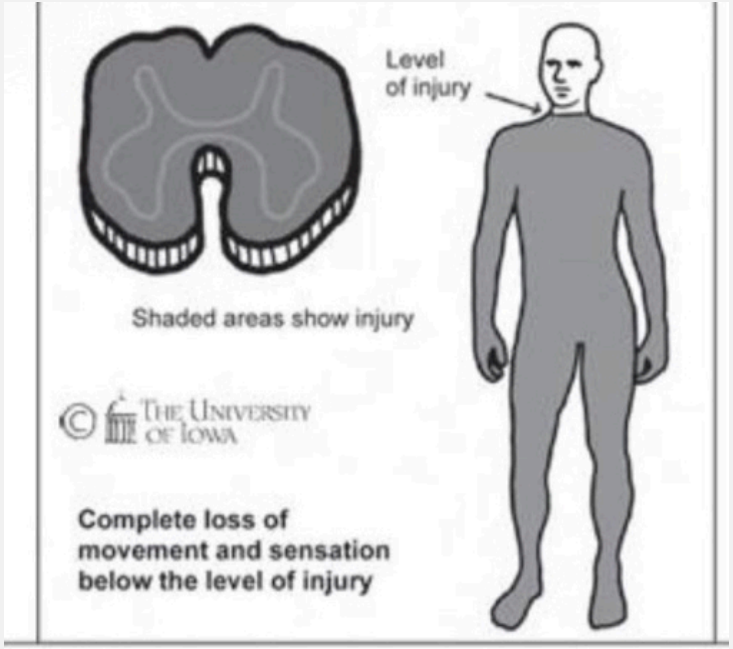
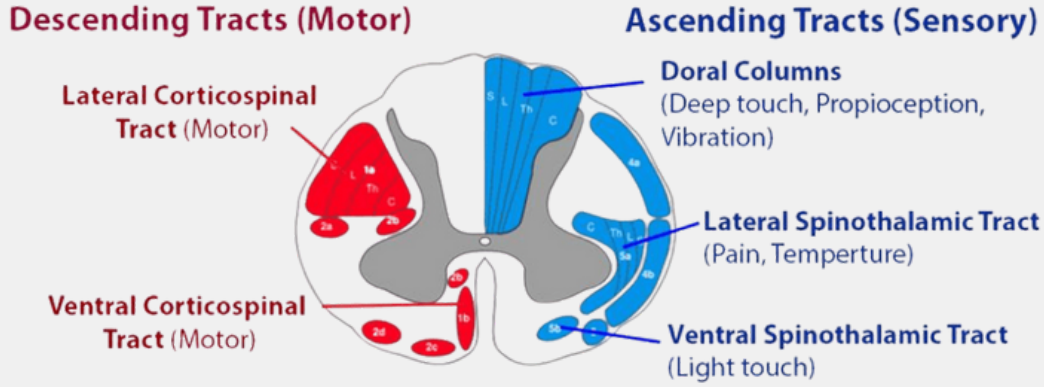


Figure 9. Complete Spinal Cord Injury

Incomplete SCI

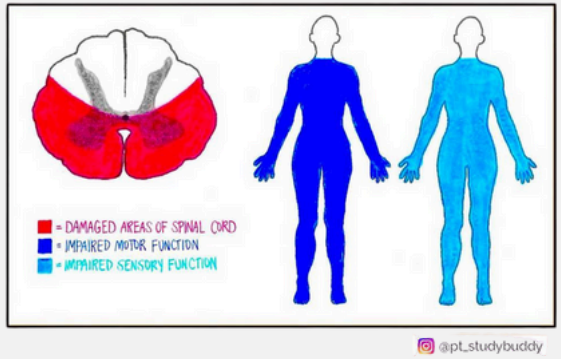
- Central cord syndrome
- Anterior cord syndrome
- Brown-Sequard syndrome
- Spinal cord injury without objective radiologic abnormality (SCIWORA)

- Descending tracts (motor)
  - lateral corticospinal tract (LCT)
  - ventral corticospinal tract
- Ascending tracts (sensory)
  - dorsal columns (DC)
    - fine touch
    - vibration
    - proprioception
  - lateral spinothalamic tract (LST)
    - pain
    - temperature
    - gross sensation
  - ventral spinothalamic tract (VST)
    - light touch



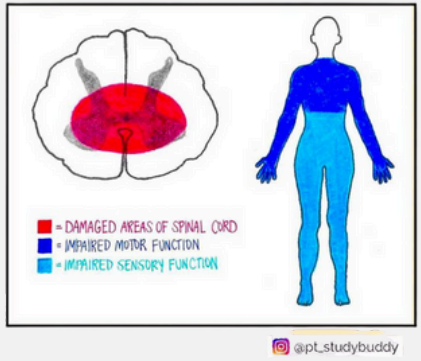
Incomplete SCI

Anterior cord syndrome



- **Most common MOI:**
  - Cervical hyperflexion
- **Damaged structures:**
  - Corticospinal tracts
  - Spinothalamic tracts
- **Impairments (below level of lesion):**
  - Bilateral UMN signs
  - Bilateral loss of motor function
  - Bilateral loss of pain, temperature, and light touch sense

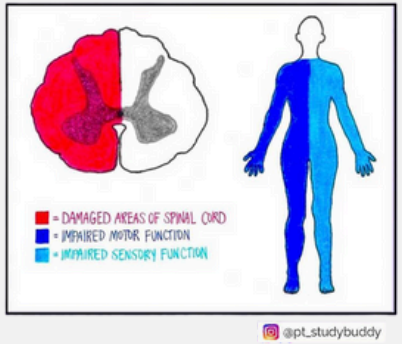
Central cord syndrome



- **Most common MOI:**
  - Cervical hyperextension (most common type of SCI)
- **Damaged structures:**
  - Corticospinal tracts
  - Spinothalamic tracts
  - DCML
- **Impairments (at level of lesion):**
  - UE involvement > LE involvement
  - Motor deficits > sensory deficits (variable sensory loss below injury)
  - Progression to bilateral UMN signs
  - May lose bowel/bladder function

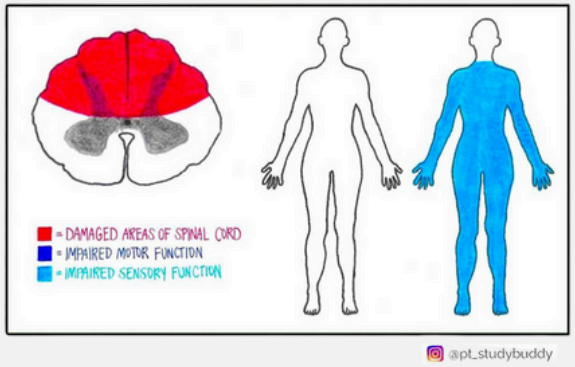
Incomplete SCI

Brown-sequard syndromes



- **Most common MOI:**
  - Stab wound
- **Damaged structures:**
  - Corticospinal tracts
  - Lateral spinothalamic tracts
  - DCML
- **Impairments (below level of lesion):**
  - Ipsilateral UMN signs
  - Ipsilateral loss of motor function
  - Ipsilateral loss of deep pressure 2-point discrimination, proprioception, and vibration sense
  - Contralateral loss of pain and temperature sense

Posterior cord syndrome

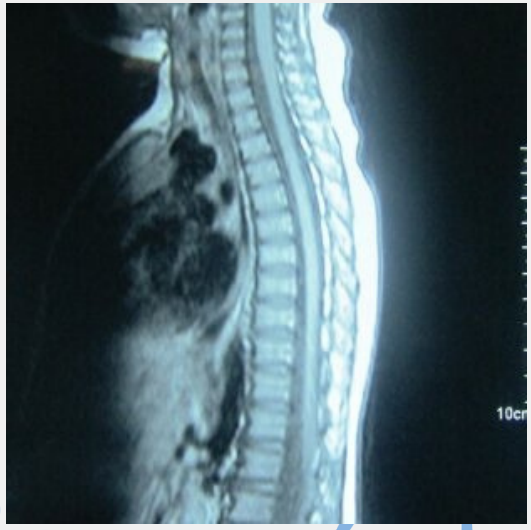


- **Most common MOI:**
  - Compression of posterior spinal artery (rarest type of SCI)
- **Damaged structures:**
  - DCML
- **Impairments (at/below level of lesion):**
  - Bilateral loss of 2-point discrimination, deep pressure, proprioception, and vibration sense

Incomplete SCI

SPINAL CORD INJURY WITHOUT RADIOLOGIC ABNORMALITY (SCIWORA).

- No bony abnormalities on plain film or CT MRI may show
- abnormalities Usually in children; symptoms may be transient at first
- Should probably lead to immobilization to prevent subsequent development of cord damage



ASIA impairment Scales

ASIA Impairment Scale		
A	No motor or sensory function is preserved in the sacral segments S4-S5	Complete
B	Sensory function preserved, but motor function is not preserved below the neurological level and includes the sacral segments S4-S5	Incomplete
C	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	Incomplete
D	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	Incomplete
E	Motor and sensory functions are normal	

STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

MOTOR

KEY MUSCLES

	R	L	
C2			
C3			
C4			
C5			Elbow flexors
C6			Wrist extensors
C7			Elbow extensors
C8			Finger flexors (distal phalanx of middle finger)
T1			Finger abductors (little finger)
T2			
T3			
T4			
T5			
T6			
T7			
T8			
T9			
T10			
T11			
T12			
L1			
L2			Hip flexors
L3			Knee extensors
L4			Ankle dorsiflexors
L5			Long toe extensors
S1			Ankle plantar flexors
S2			
S3			
S4-5			

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

Voluntary anal contraction (Yes/No)

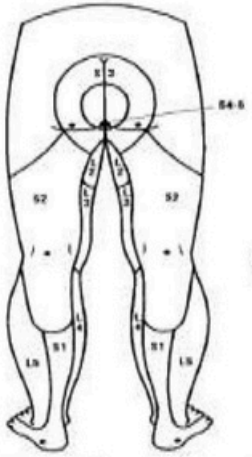
TOTALS (MAXIMUM) (50) + (50) = (100) **MOTOR SCORE**

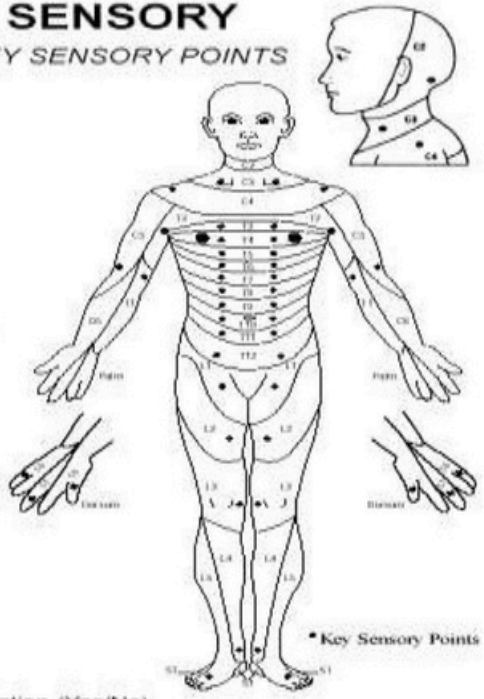
SENSORY

KEY SENSORY POINTS

	LIGHT TOUCH R	LIGHT TOUCH L	PIN PRICK R	PIN PRICK L
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				
S4-5				

0 = absent
1 = impaired
2 = normal
NT = not testable





Any anal sensation (Yes/No)

TOTALS (MAXIMUM) (56) (56) + (56) (56) = **PIN PRICK SCORE** (max: 112)

LIGHT TOUCH SCORE (max: 112)

NEUROLOGICAL LEVEL
The most caudal segment with normal function

SENSORY R L
MOTOR

COMPLETE OR INCOMPLETE?
Incomplete = Any sensory or motor function in S4-S5

ASIA IMPAIRMENT SCALE

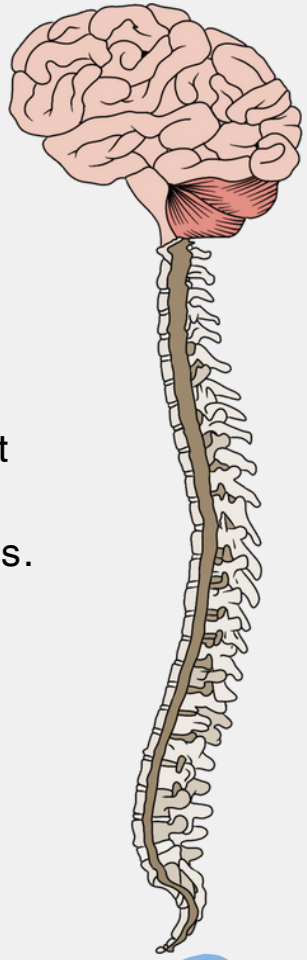
ZONE OF PARTIAL PRESERVATION
Caudal extent of partially innervated segments

SENSORY R L
MOTOR

2000 Rev.

Level of spinal injury

- C1–C3 injury → no diaphragm function; ventilator needed.
- C3–C5 injury → phrenic nerve affected (“C3,4,5 keep the diaphragm alive”) → weak breathing.
- T1–T5 injury → sympathetic cardiac fibres disrupted (“T1–T5 keeps your heart alive”) → bradycardia, hypotension.
- T6–T12 injury → heart and diaphragm spared; abdominal/intercostal weakness.
- S2–S5 injury → loss of bowel, bladder, sexual and anal sphincter control.

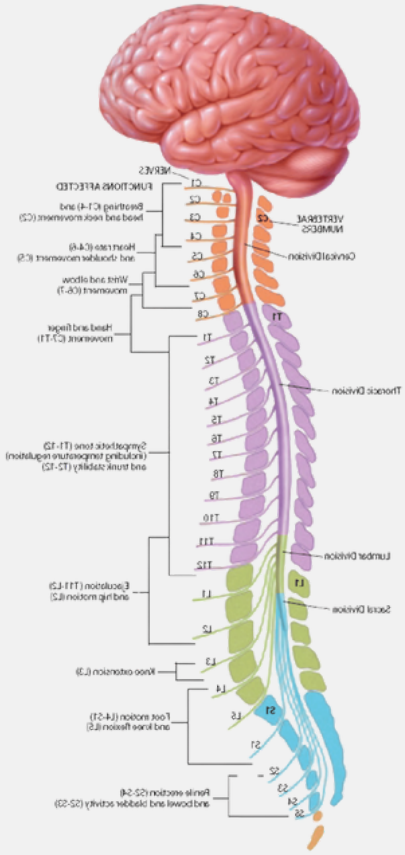


NEURAL CONTROL OF BLOOD PRESSURE & BLOOD FLOW

- Complete lesions above T1 will eliminate all sympathetic outflow

- Lesions between T1 and T6 will preserve sympathetic tone in the head and upper extremities but deny it to the adrenals and the lower extremities.

- Lesions between T6 and the lumbar cord will preserve adrenal innervations but denervatethe lower extremities



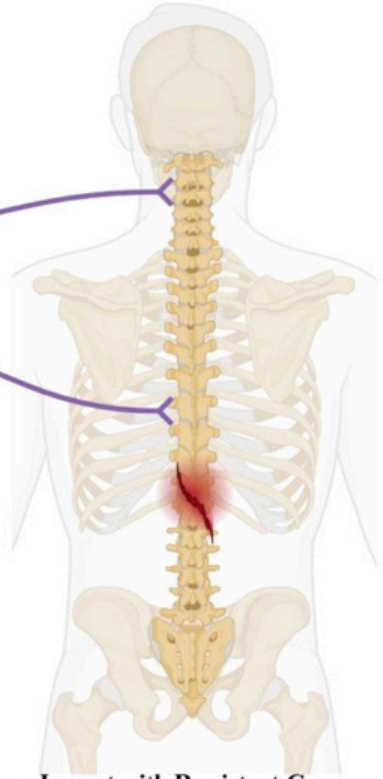
Spinal Shock

- Loss of Motor, Sensory, Autonomic and Reflexive Function
- Four Phase Progression
- Lasts Months

Neurogenic Shock

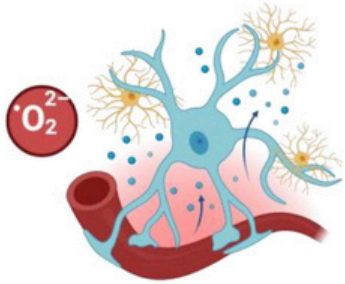
- Injuries above the T6 level
- Hypodynamic Instability
- Sudden Loss of Autonomic Tone

Primary Injury



- **Impact with Persistent Compression**
- **Impact Alone**
- **Distraction**
- **Laceration/Transection**

Secondary Injury



- **Neuroinflammation**
- **Ischemia**
- **Free radical formation**
- **Lipid Peroxidation**
- **Breakdown of Blood-Brain Barrier**
- **Edema**
- **Protease Release**
- **Excitotoxicity**

Time

Spinal shock vs neurogenic shock

Spinal Shock	Neurogenic Shock
Due to acute cervical spinal cord injury	Due to injury T6 and above
○ Temporary suppression of all reflex activity below the level of injury	○ The body's response to the sudden loss of sympathetic control
Acute onset	**Delayed onset** hours to days after trauma
1. Decreased/Absent reflexes **2. Loss of sensation** **3. Flaccid paralysis below injury**	**1. Hypotension - due to massive vasodilation** **2. Bradycardia - due to unopposed parasympathetic stimulation** **3. Hypothermia - Unable to regulate temperature.**
Transient < 48 hrs	Onset hours to days after trauma; lasts 1-3 weeks
Look for loss of the bulbocavernous reflex and the anal wink.	
Spinal shock & neurogenic shock can be present in the same patient	

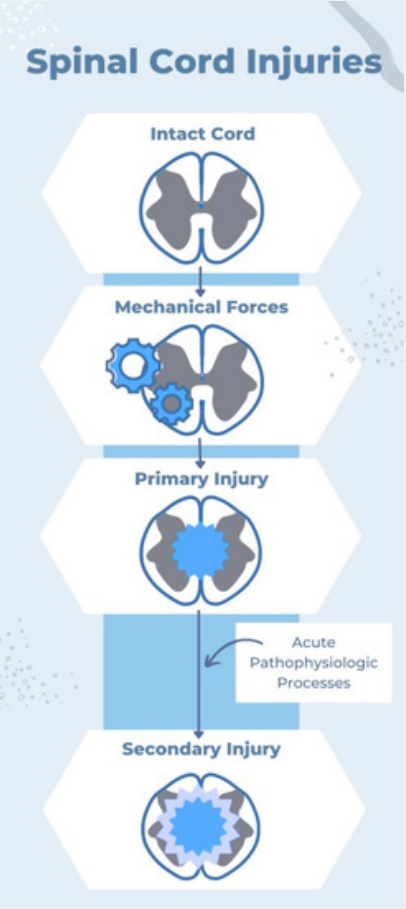
SECONDARY INJURY

After the initialmacroscopicinjury,secondaryinjuries are an important cause of disability

Movement of unstable spine.

Vascular insufficiency

Free radical induced damage



MANAGEMENT

1□ Initial & ABCs

- **Airway, Breathing, Circulation (ABCs)** first priority.
- If **intubation** is needed → in-line cervical stabilization.
- Direct **laryngoscopy or fiberoptic** can be used depending on the situation.
- **Log-rolling** during transfers to prevent further cord injury.
- Consider possible concomitant head injury.

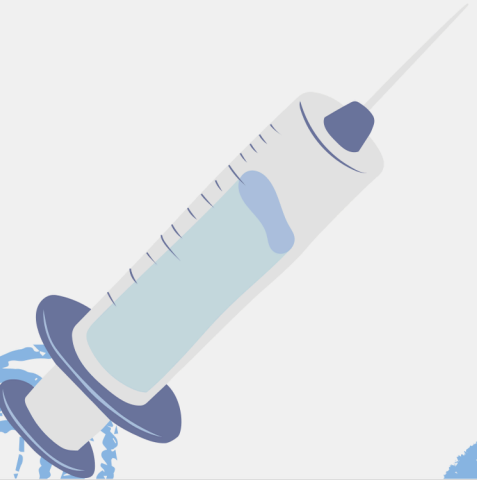
2□ Volume & Hemodynamic Support

- **Volume resuscitation** cannot be guided solely by physical findings.
- **Hypotension + bradycardia may persist despite fluids (saline/colloid).**
- Replace missing sympathetic tone with **vasopressors**:
  - Phenylephrine (if normal/high heart rate).
  - Norepinephrine (if bradycardic).
- **Avoid/correct hypotension** (SBP < 90 mmHg).
- **Maintain MAP 85–90 mmHg** for first 7 days (recommended to prevent cord ischemia).

MANAGEMENT

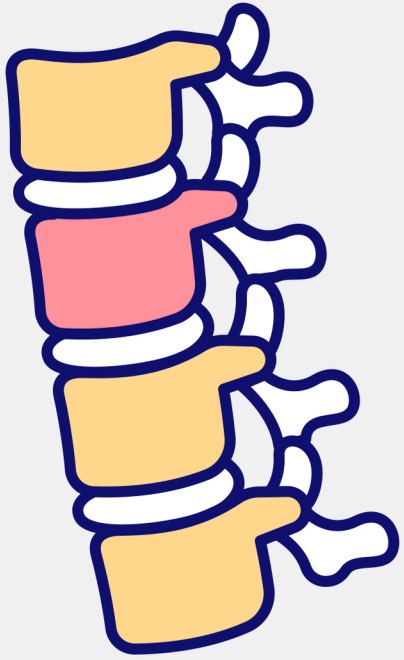
3□ Spinal Perfusion Pressure Management

- Concept similar to cerebral perfusion pressure in head injury.
- Aim: raise BP to prevent cord ischemia and limit secondary injury.
- Hypotension and hypoxia worsen outcomes just like in TBI.

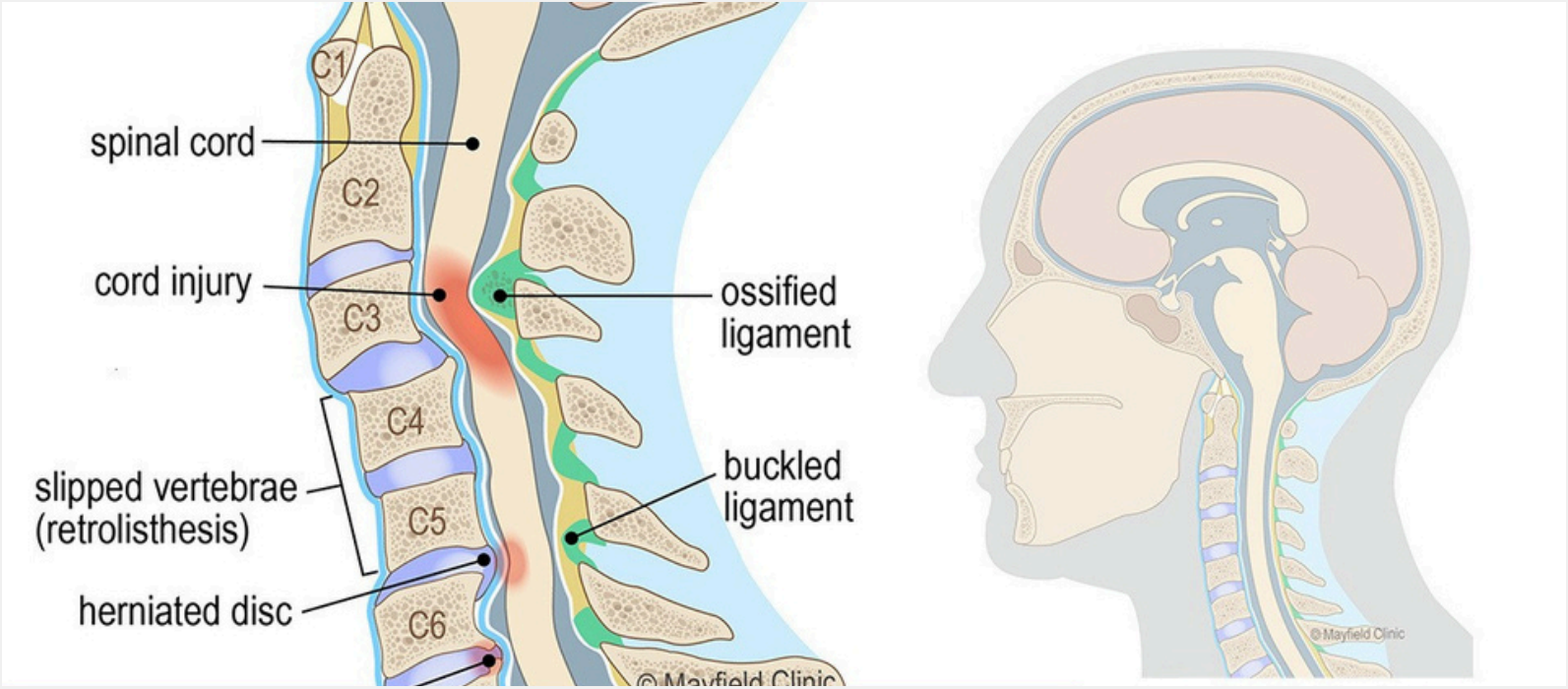


Acute non-traumatic spinal cord injuries:

1. Disc
2. Tumor
3. Infection
4. Hemorrhage
5. Iatrogenic.



Cervical Disc with Myelopathy



Cervical Disc with Myelopathy

Clinical Features:

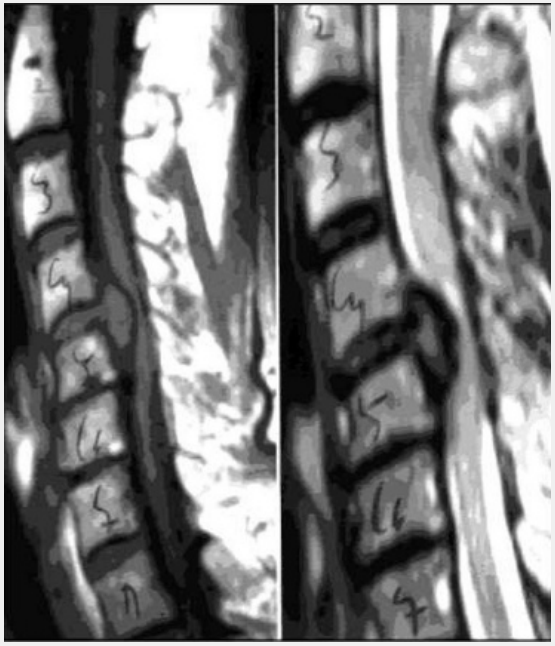
Neck Pain

Hand Numbness.

Weakness

Unsteadiness

Hyperreflexia



Lumbar Disc

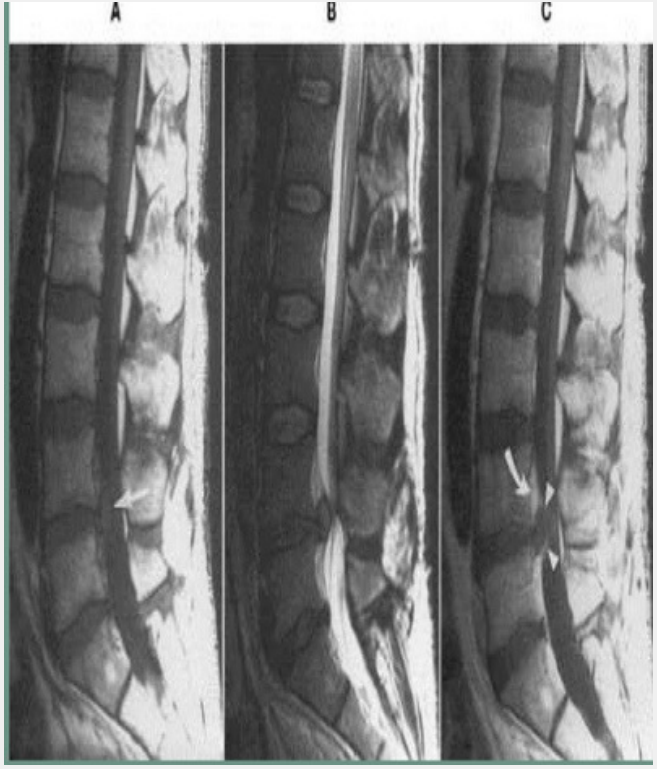
Clinical Features:

Lowback pain

Sphincter disturbance retention, incontinence, rectal tone.

Saddle anesthesia

Radicular symptoms (multiple roots) weakness



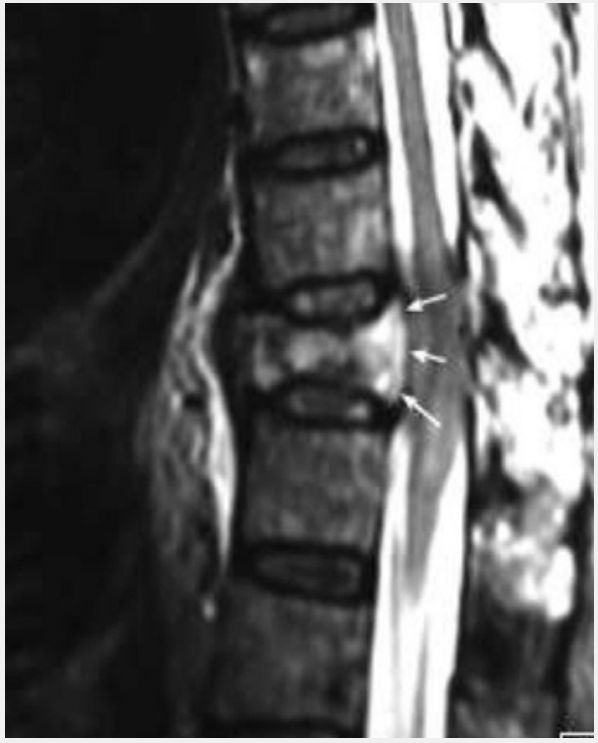
Spinal Metastases

Clinical Features:

Cancer patient withback pain

>20% of cancer patients

Lung, breast, GI, Prostate, melanoma, lymphoma, kidney



Thank you very much!