



SOCIETY OF TRAUMA NURSES

# THE ELECTRONIC LIBRARY OF TRAUMA LECTURES



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# TRAUMA LECTURES

## Spinal Column and Spinal Cord Injuries



SOCIETY OF TRAUMA NURSES





# Objectives

**At the conclusion of this presentation  
the participant will be able to:**

- Identify the components of the spine
- Assess for spine and spinal cord injury
- Discuss the initial management of the spinal cord injured patient
- Evaluate the long term needs of the spinal cord injured patient
- Describe the systemic effects of spinal cord injury



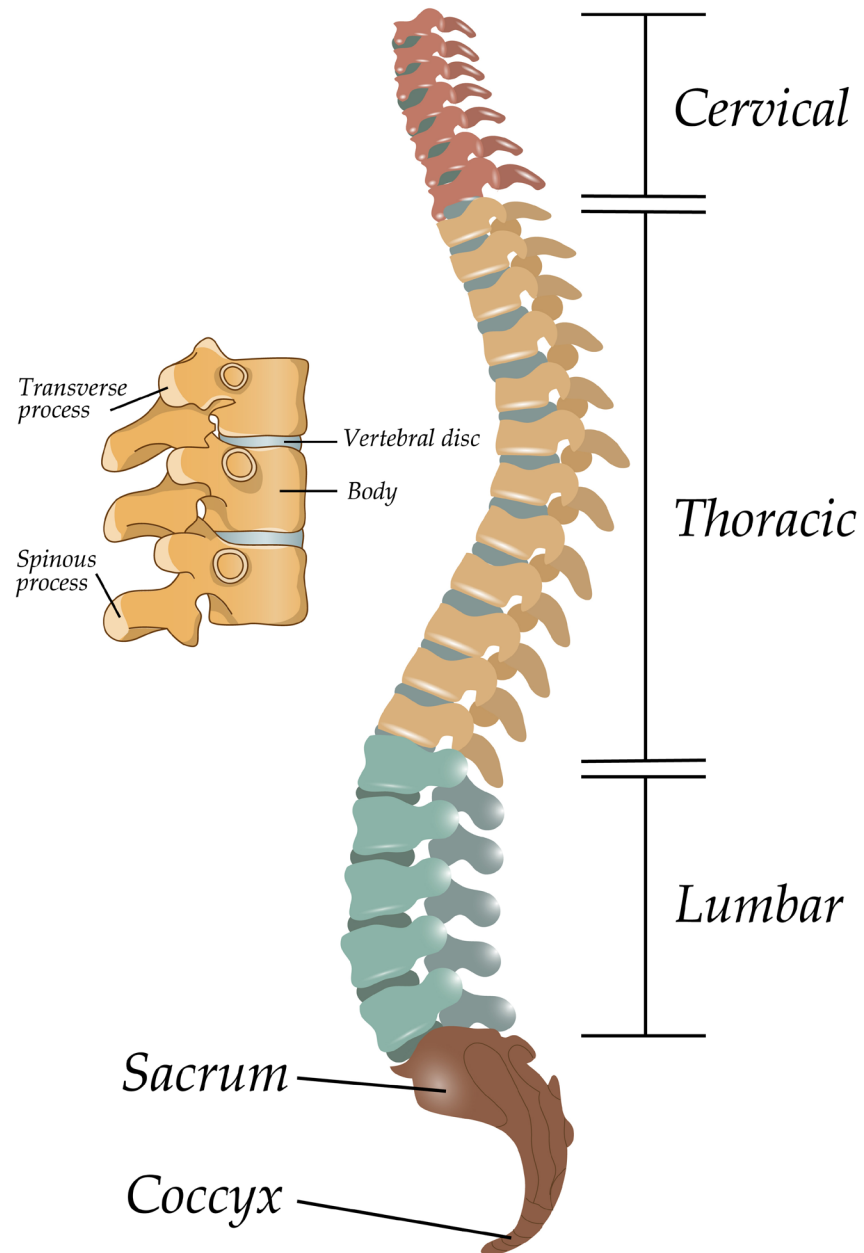


# Epidemiology

- Approximately 17,810 new cases per year
- Average age at injury is 43 years
- Male - 78%
- Incidence:
  - Non-Hispanic whites: 59%
  - Non-Hispanic blacks: 24%
  - Hispanic origin: 13%
- Most common causes – Motor Vehicle Crashes (38.6%), Falls (32.2%) and Violence (14%)
- Bimodal distribution of occurrence
  - Adolescence and over 65 years of age



# Anatomy and Physiology



- Vertebrae
- Discs
- Ligaments
- Spinal cord
- Blood vessels

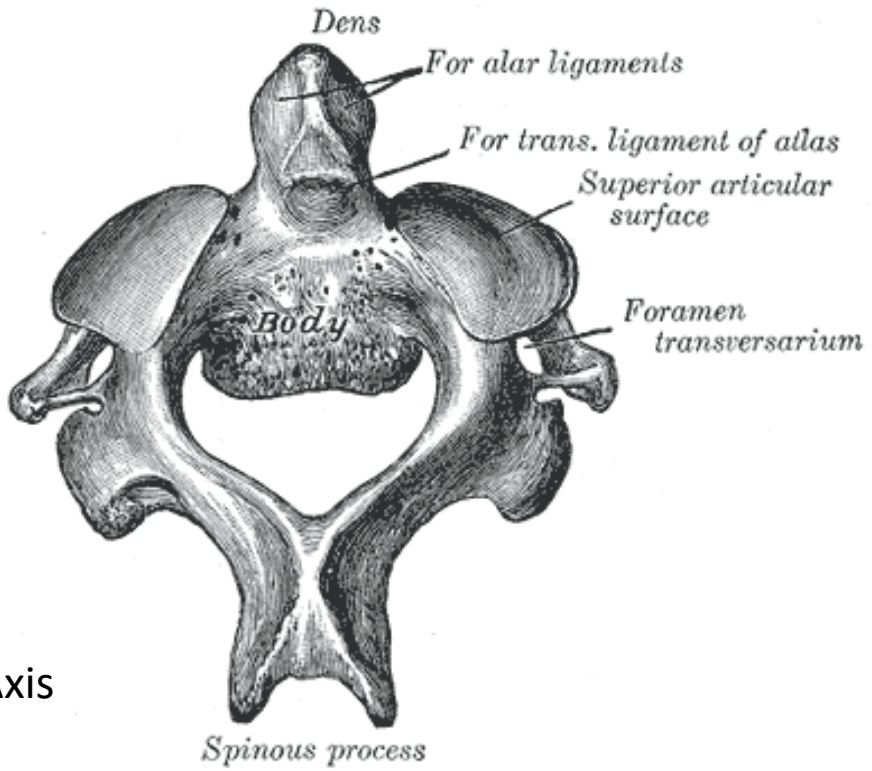




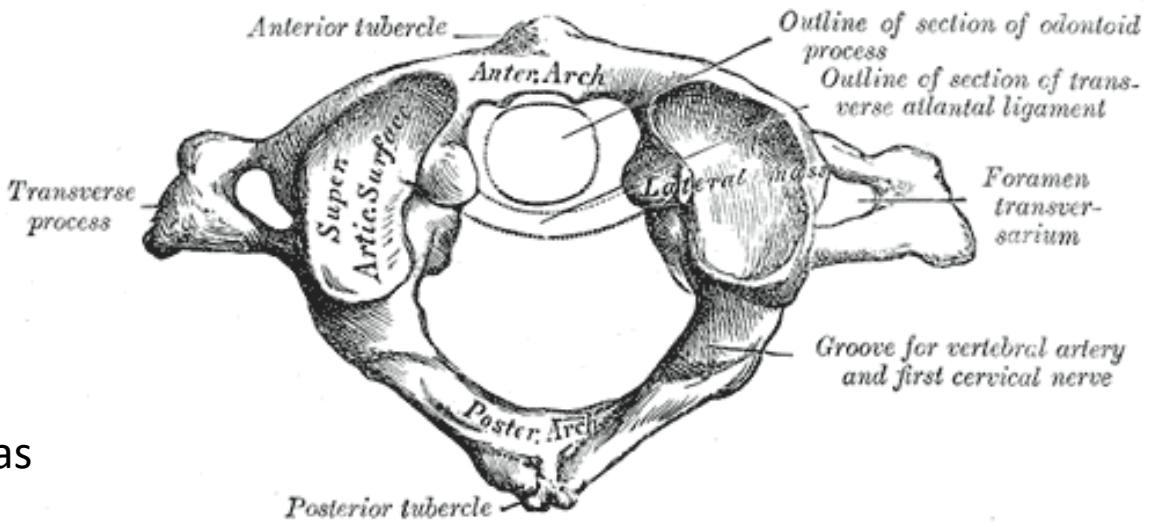
# Cervical Vertebrae



C2 Axis



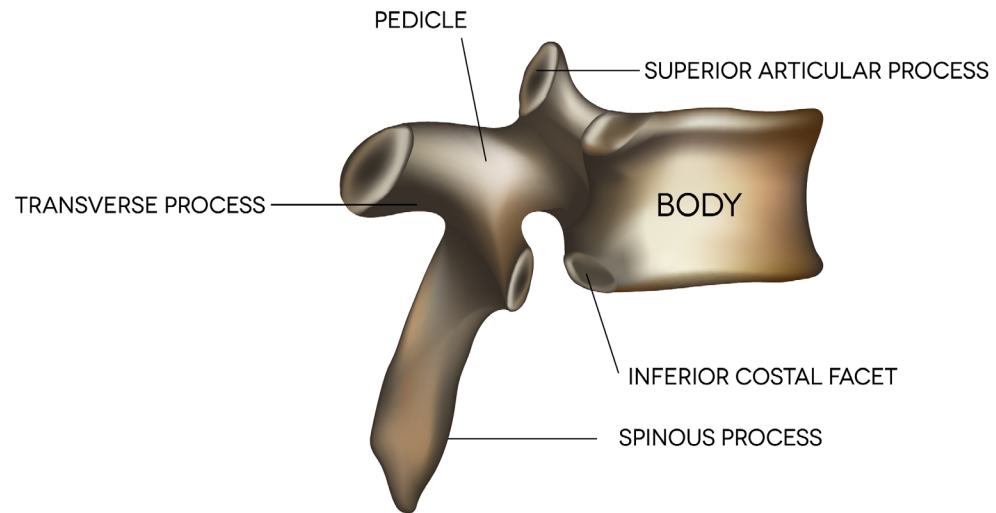
C1 Atlas



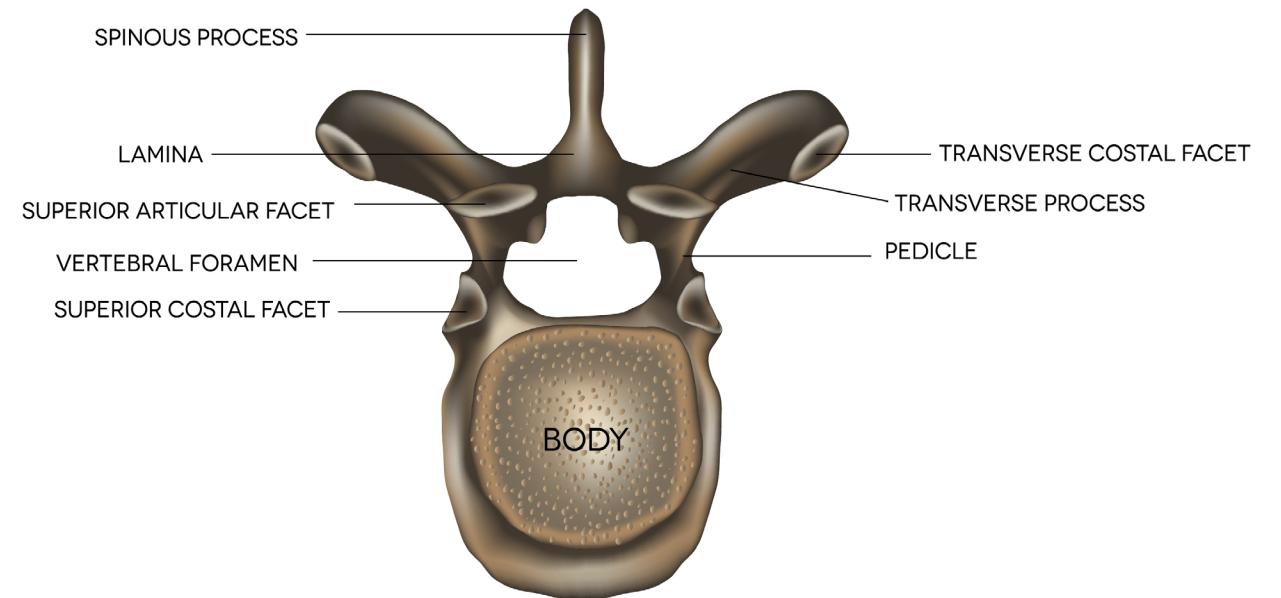


# Thoracic Vertebra

THORACIC VERTEBRA (SIDE VIEW)

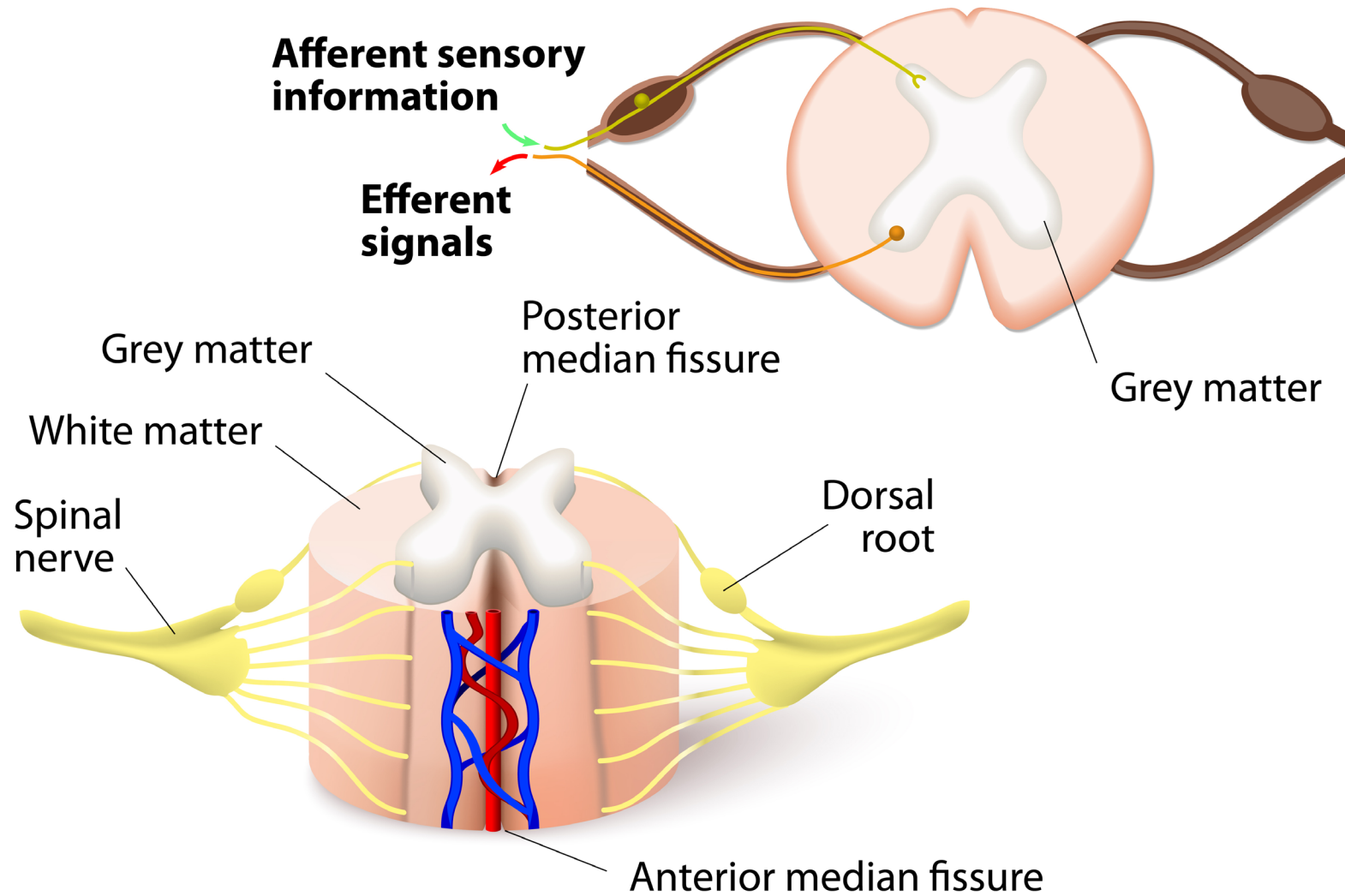


THORACIC VERTEBRA (OVERHEAD VIEW)





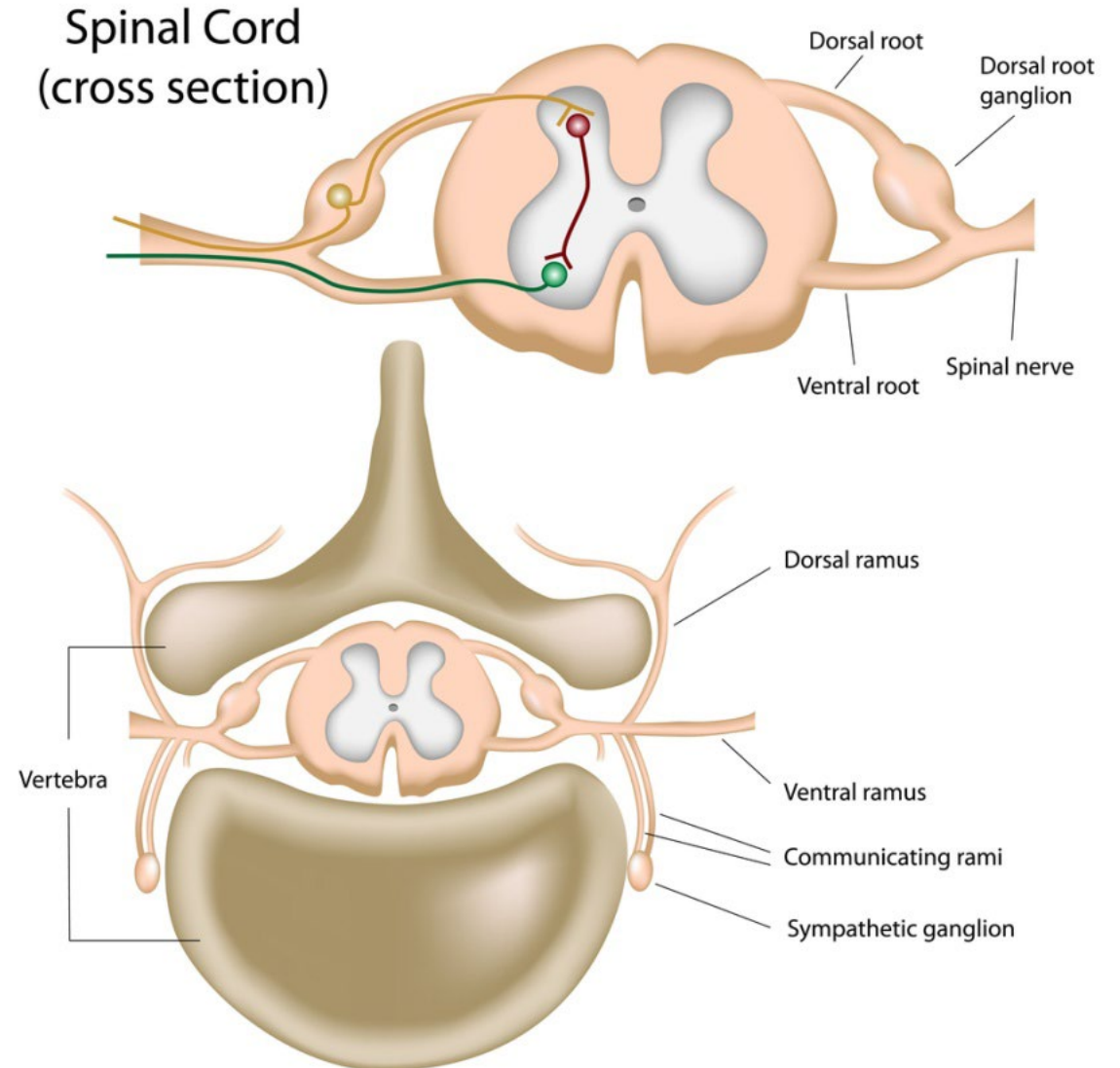
# Spinal Cord





# Spinal Cord

- Gray Matter
  - Anterior – motor
  - Inter-mediolateral – sympathetic/parasympathetic
  - Posterior – sensory
- White Matter
  - Anterior – motor
  - Lateral – 8 tracts
  - Posterior – position





# Spinal Cord

**Motor and descending (efferent) pathways (red)**

## **Pyramidal tracts**

- Lateral corticospinal tract
- Anterior corticospinal tract

## **Extrapyramidal Tracts**

- Rubrospinal tract
- Reticulospinal tracts
- Olivospinal tract
- Vestibulospinal tract

**Sensory and ascending (afferent) pathways (blue)**

## **Dorsal Column Medial Lemniscus System**

- Gracile fasciculus
- Cuneate fasciculus

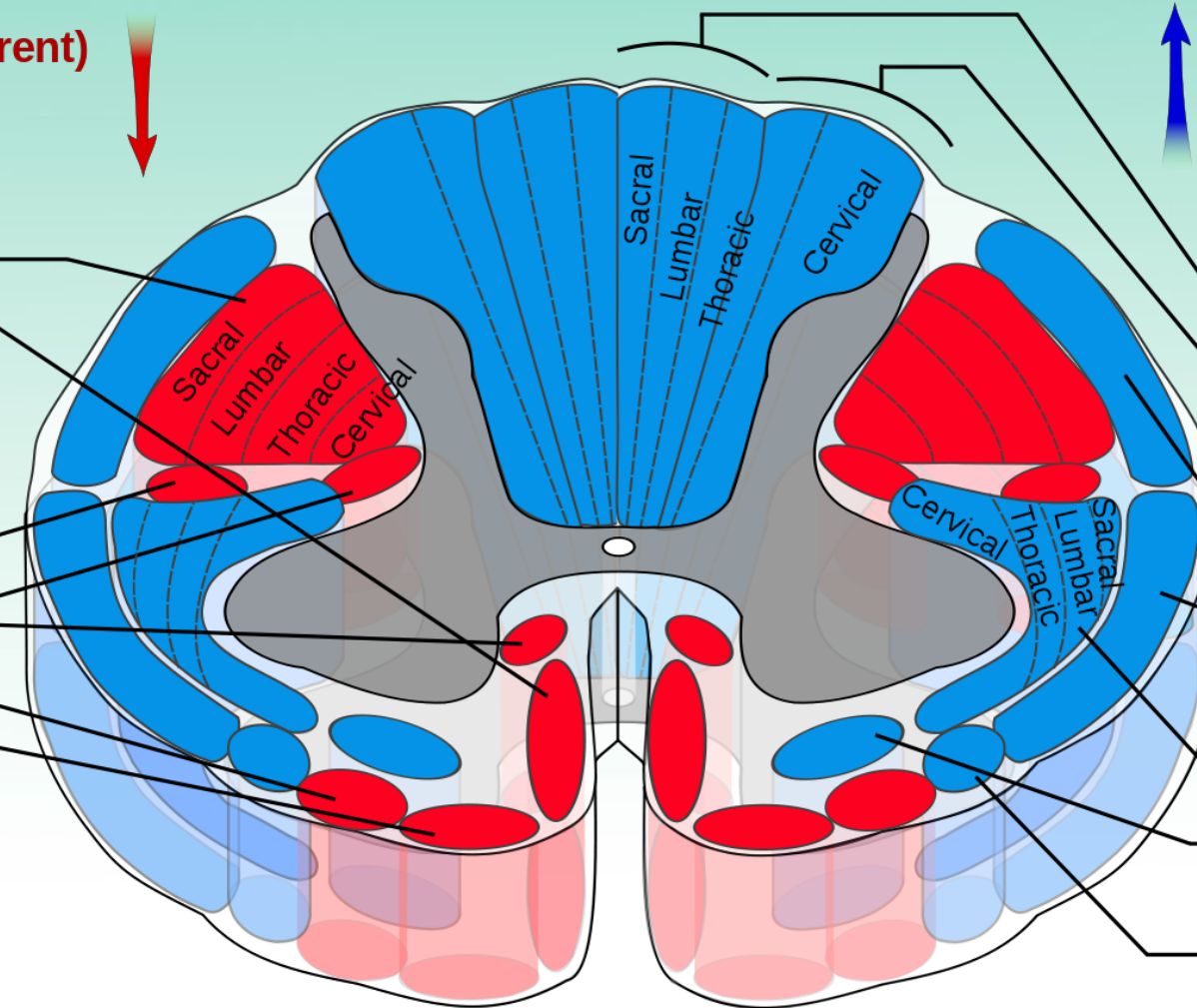
## **Spinocerebellar Tracts**

- Posterior spinocerebellar tract
- Anterior spinocerebellar tract

## **Anterolateral System**

- Lateral spinothalamic tract
- Anterior spinothalamic tract

Spino-olivary fibers



Polarlys and Mikael Häggström, CC BY-SA 3.0 via Wikimedia Commons



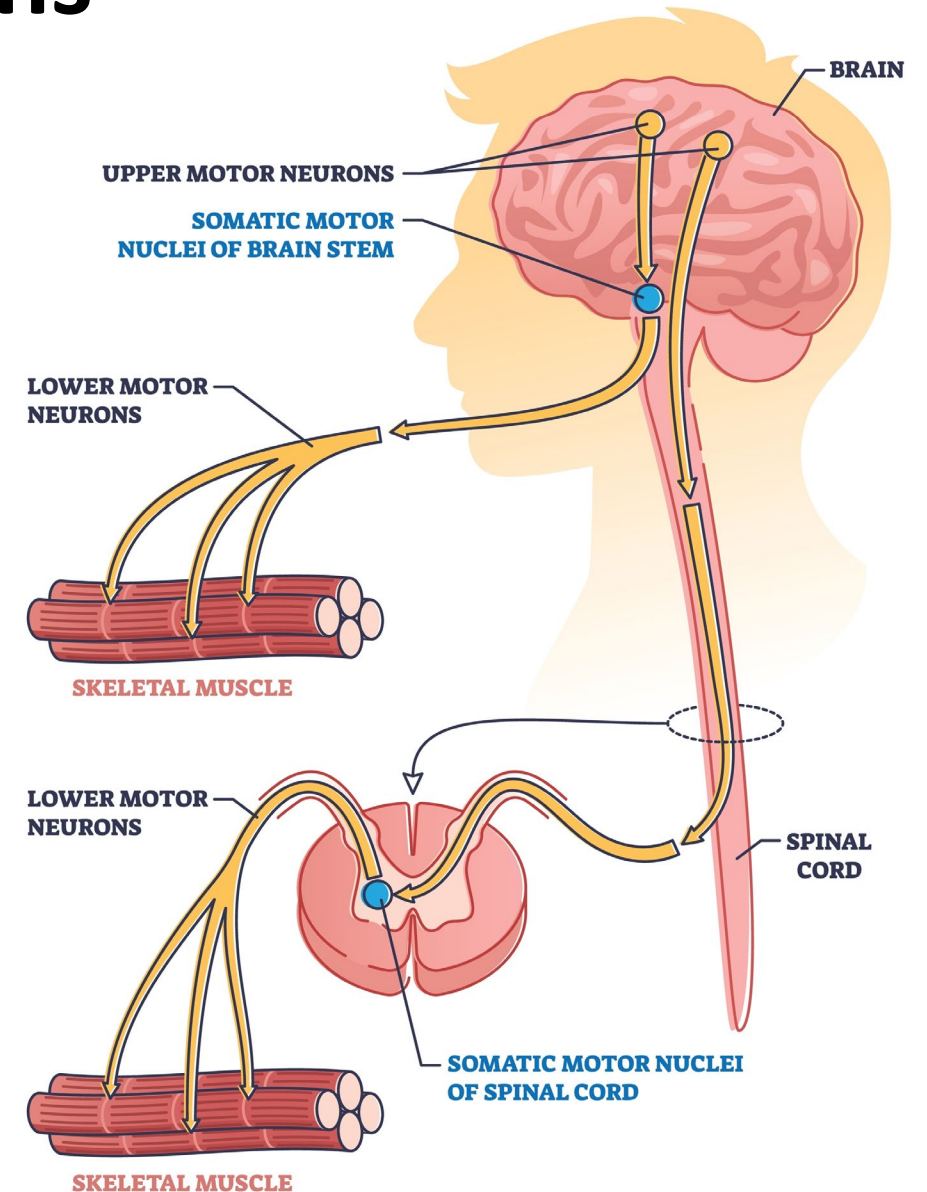
# Motor Neurons

## Upper motor neuron (UMN)

- Project from the motor strip in the cerebral cortex
- Fully contained in the CNS
- Injury = paralysis, hypertonicity, hyperreflexia

## Lower motor neuron (LMN)

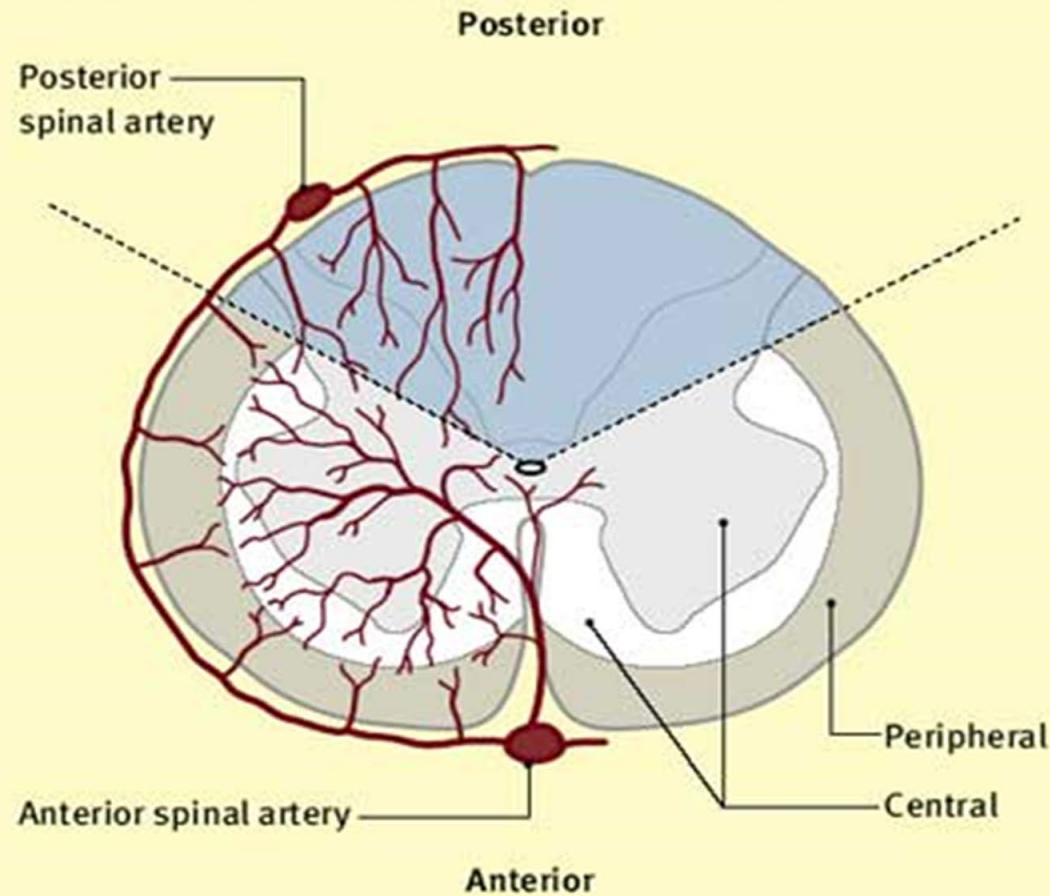
- Located in the ventral horn of the spinal cord
- Injury = flaccidity, hyporeflexia, fasciculations





# Blood Supply Spinal Cord

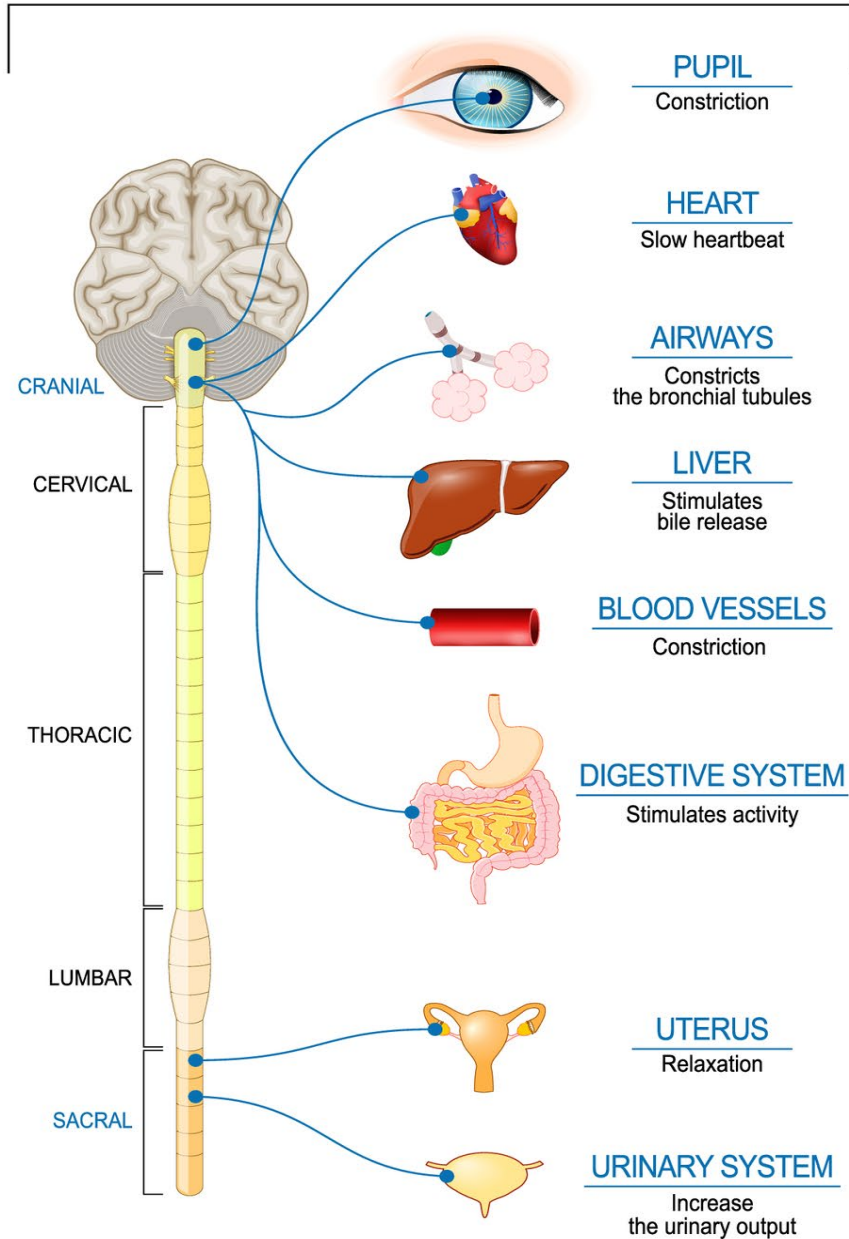
## Blood supply to the spinal cord: horizontal distribution



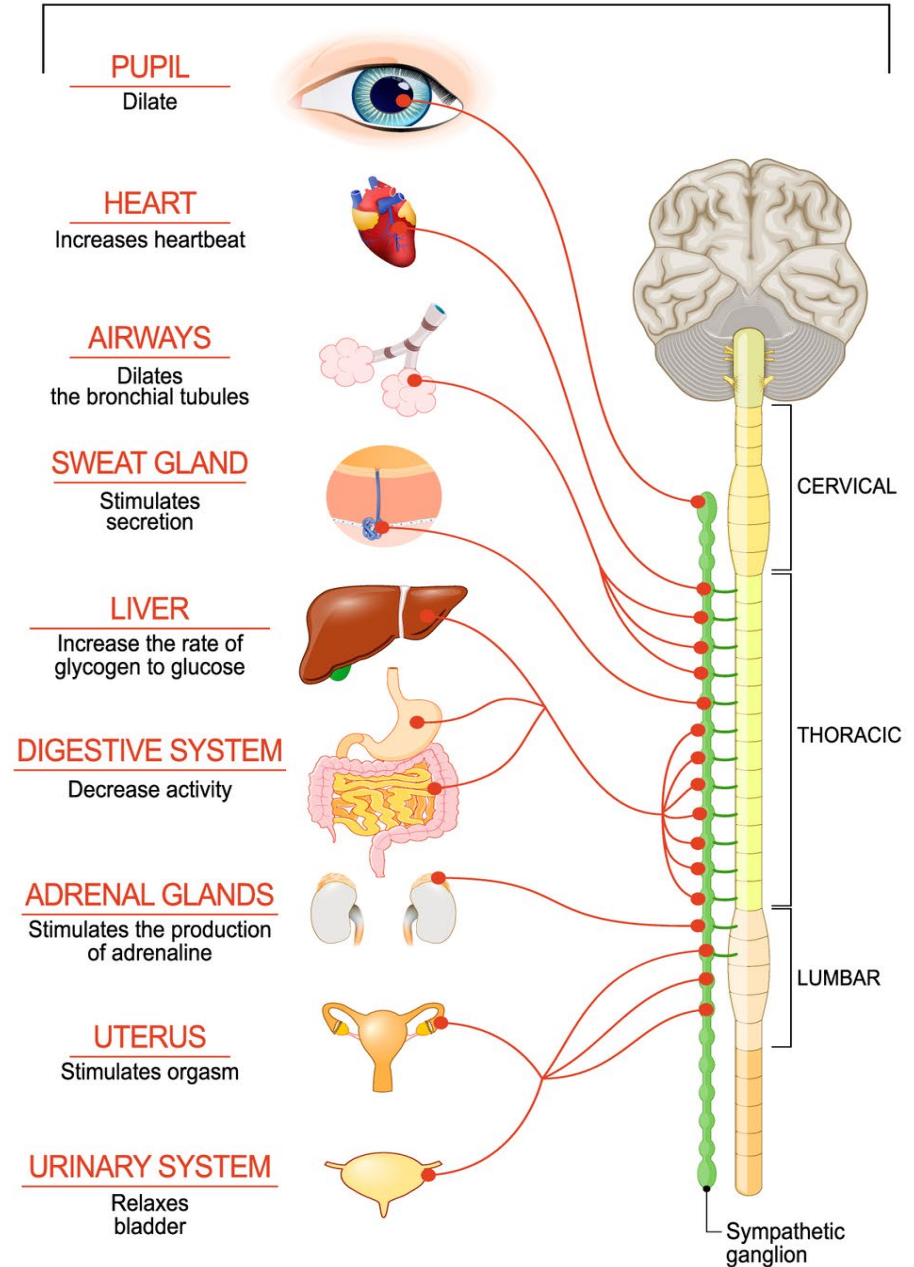
The central area supplied only by the anterior spinal artery is predominantly a motor area



# Parasympathetic

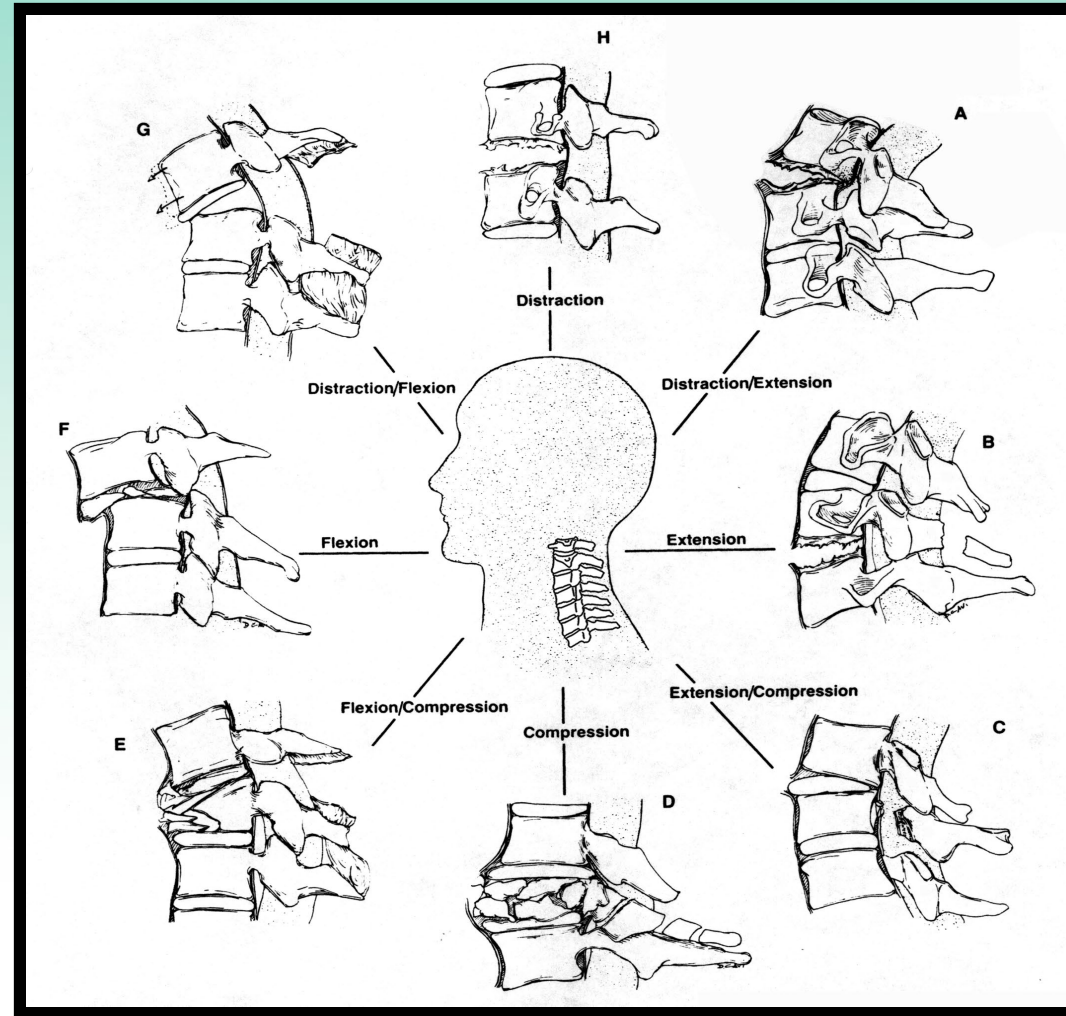


# Sympathetic





# Mechanisms of Injury



McQuillan, et al, 2002. Reprinted with permission



# Memory Aid for Cervical Fractures







# Initial Management

Pre-hospital

Resuscitation





# Sensorimotor Assessment

Lateral corticospinal tract

Lateral spinothalamic tract

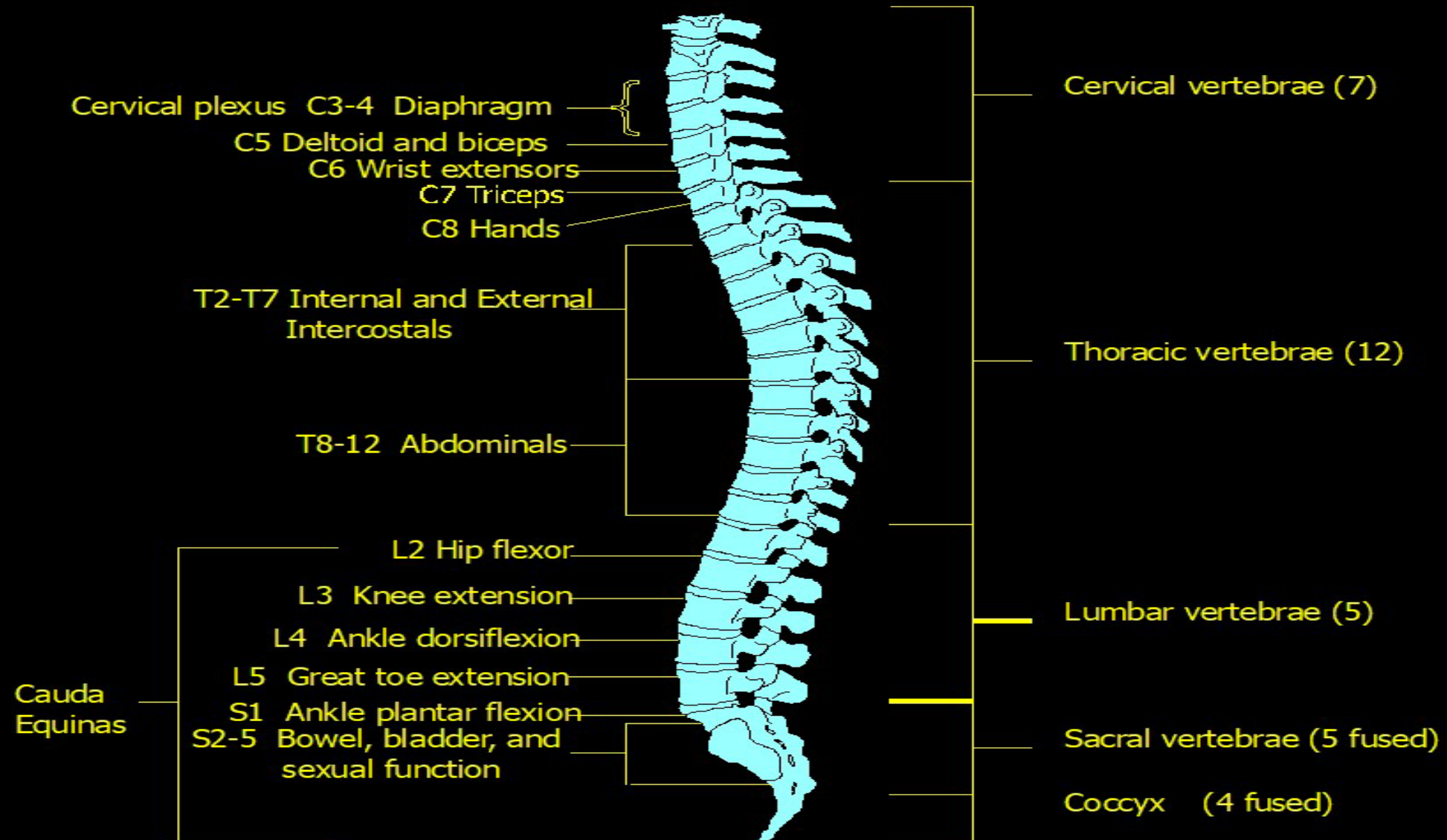
Dorsal column



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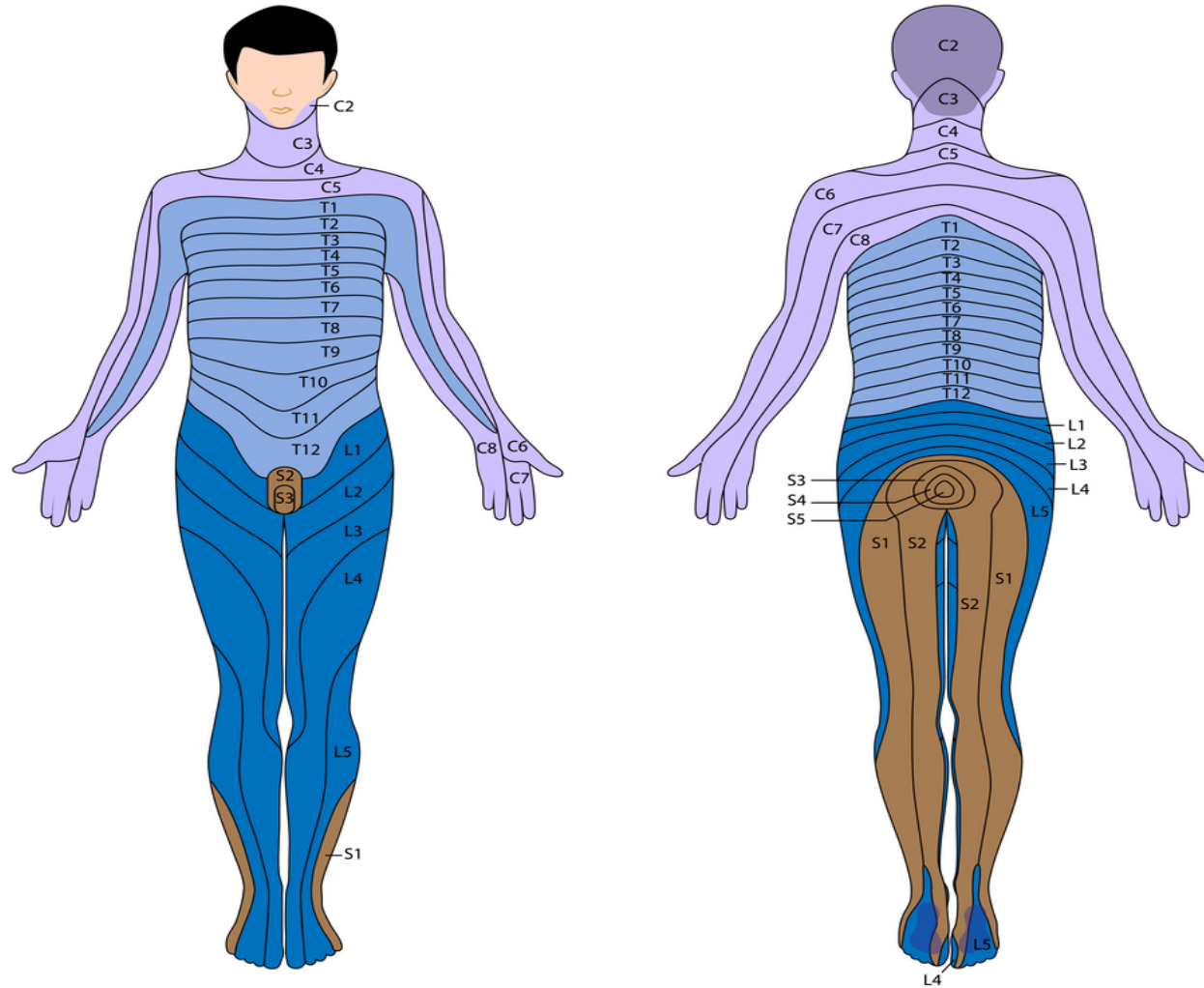


# Motor Assessment





# Dermatomes Sensory Assessment








# Reflex Assessment

- Test for sensory/motor sparing
- Major deep tendon reflexes (DTR) assessed
  - Biceps (C5)
  - Brachioradialis (C5-6)
  - Triceps (C7-8)
  - Quadriceps (knee-jerk) (L3-4)
  - Achilles (S1-2)
- Scoring 0 to +++++





# Superficial Reflex Assessment



Abdominal - umbilicus pulls toward stimulus
Cremasteric - scrotum pulls up with stroking inner thigh
Bulbocavernosus - anal sphincter contraction with stimulus
Superficial anal – anal sphincter contraction with stroking peri-anal area
Priapism – results with tugging on catheter





# Spinal Cord Injury

- Primary
  - From the time of initial mechanism of injury
- Secondary
  - The cell damage that occurs as a result of decreased perfusion, hypoxia, inflammation and/or hemorrhage to the spinal cord





# Spinal Cord Injury

## ASIA Impairment scale

- Complete (A) – lack of motor/sensory function in sacral roots (S4-5)
- Incomplete (B) – sensory preservation, motor loss below injury including S4-5
- Incomplete (C) – motor preservation below injury, more than ½ muscle groups motor strength  $<3$
- Incomplete (D) - motor preservation below injury, at least 50% muscle groups motor strength  $\geq 3$
- Normal (E) – all motor/sensory function present



# Central Cord Syndrome

- Typically fall with hyperextension
- Elderly
- Presents with weak upper extremities, variable bowel and bladder dysfunction, disproportionately functional lower extremities



Knipe, H. Radiopaedia.org



# Anterior Cord Syndrome

- Primarily a hyperflexion mechanism
- Anterior segment of spinal cord controls motor function below the injury







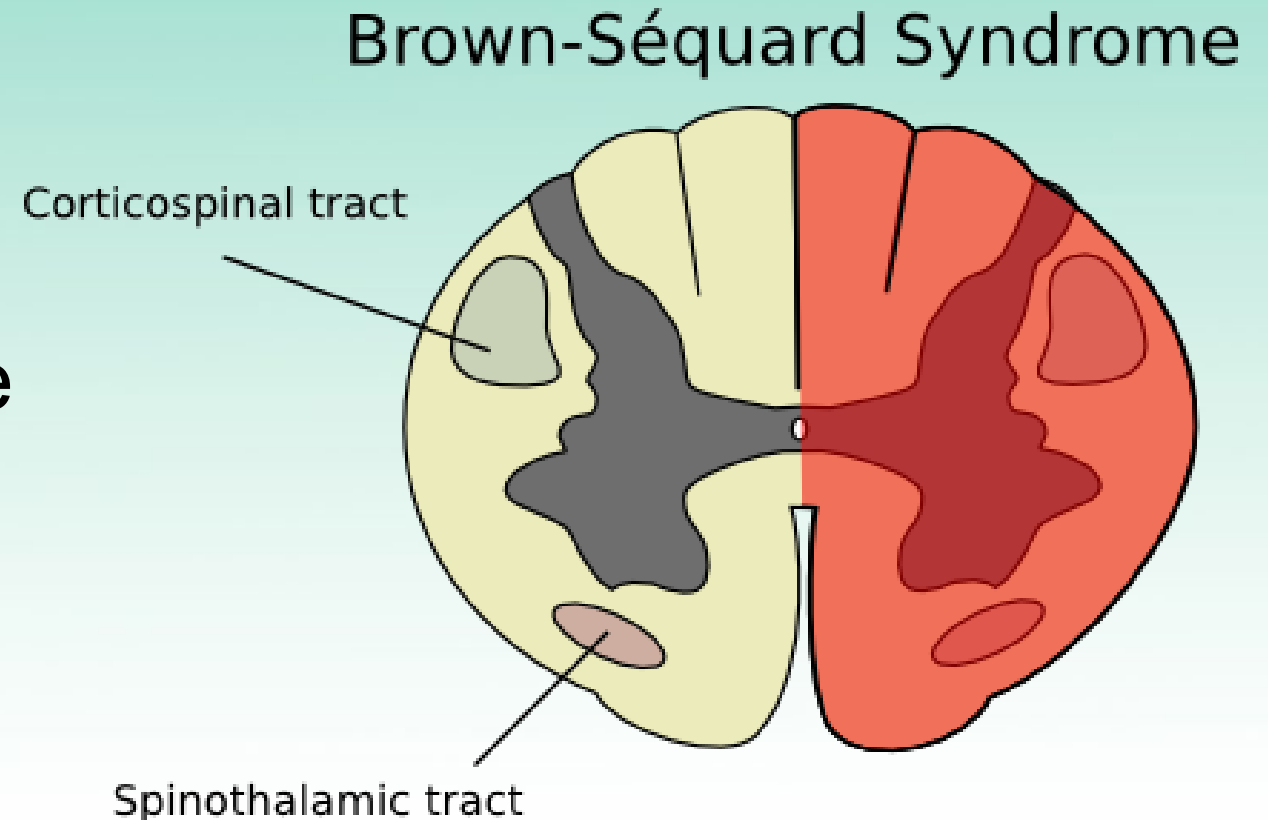
# Posterior Cord Syndrome

- Rare injury
- Loss of posterior column function
- Deep touch, proprioception, vibration
- Maintain the ability to walk but rely on visual input for spatial orientation



# Brown-Sequard Syndrome

- Hemisection of the cord usually from penetrating injury
- Loss of motor on same side as injury
- Loss of sensation on the opposite side



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# Incomplete Cord Syndromes

- **Sacral Sparing**
  - Presence of perianal sensation and anal sphincter tone
- **Conus Medullaris**
  - S4-5 exit at L1; may have L1 fracture
  - Areflexic bowel and bladder, flaccid anal sphincter
  - Variable lower extremity loss
- **Cauda Equina**
  - Lumbar sacral nerve roots, with or without fracture
  - Variable loss; areflexia; radicular pain





# Complete Cord Injury

## Quadriplegia (Tetraplegia)

- Loss of function below the level of injury
- Includes sacral roots (bowel and bladder)
- C1-T1

## Paraplegia

- Loss of function below the level of injury
- Below T1



# Diagnostics

- **Plain Films**
- **CT Scan**
  - Preferred imaging modality according to EAST and the American College of Radiology
- **MRI Scan**
  - Demonstrates ligamentous injury
  - Degree of compression and cord canal impingement







# C Spine Clearance

## Clinical

- Awake, alert, and oriented
- NO distracting injuries
- NO drugs or alcohol that alter experience
- NO pain or tenderness
- NO focal neurologic deficits

## Imaging

- Films, CT, MRI
- Complaints of neck pain
- Neurologic deficit
- Altered level of consciousness, ventilator



# Fractures-Dislocations

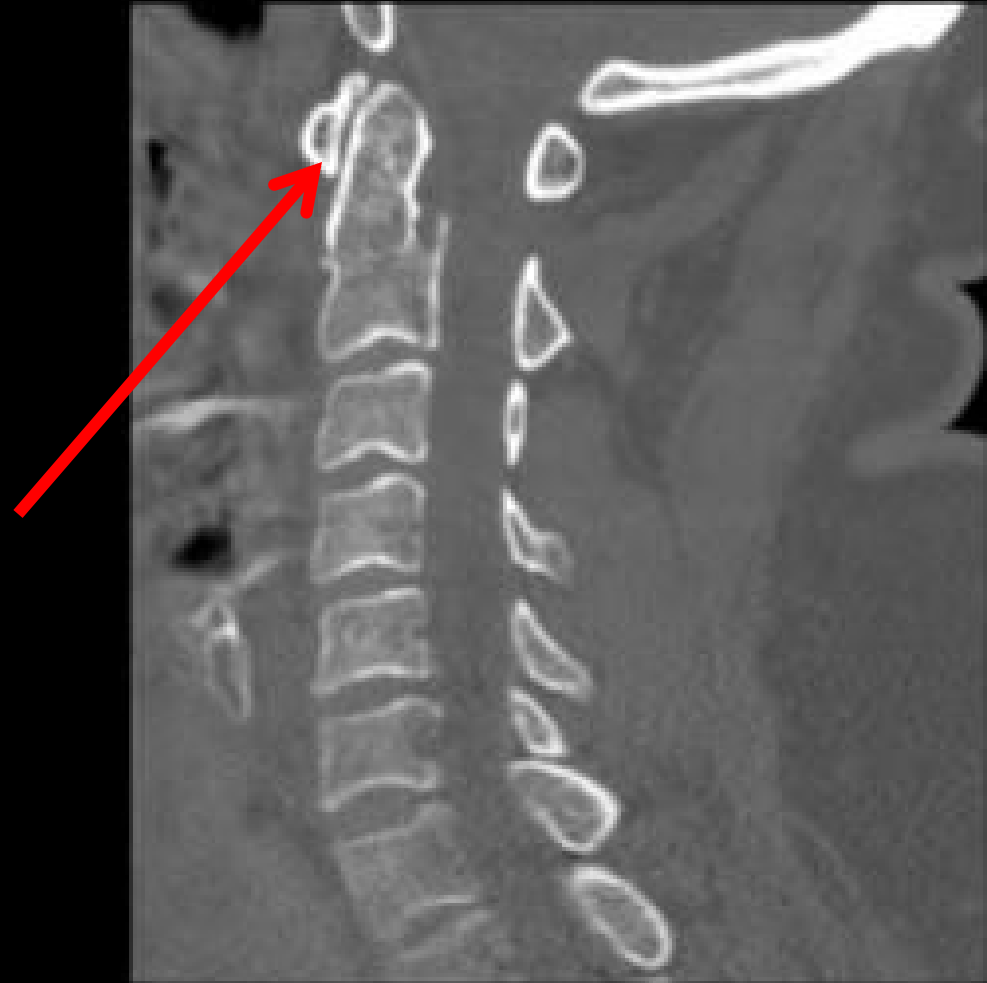
- **Atlanto-occipital dissociation**
  - Complete injury; death
- **Atlanto-axial dislocation**
  - Complete injury; death
- **Jumped, Jump-locked facets**
  - Require reduction; may impinge on cord; unstable due to ligamentous injury





# Fractures-Dislocations

- Facet fractures
  - High incidence of cord injury in cervical spine
- Odontoid (dens) fractures
  - Rarely cord injury





# Fractures-Dislocations

- Compression
- Burst
- Chance







# SCIWORA

## Spinal Cord Injury without Radiographic Abnormality

- Most frequently children
- Dislocation occurs with spontaneous relocation
- Cord injury evident
- Radiographs negative





# Management

- **Airway**

- C1-4 injuries require definitive airway
- Injuries below C4 may also require airway due to:
  - Work of breathing
  - Weak thoracic musculature

- **Breathing**

- Adequacy of respirations
  - SpO<sub>2</sub>
  - Tidal volume
  - Effort
  - Pattern







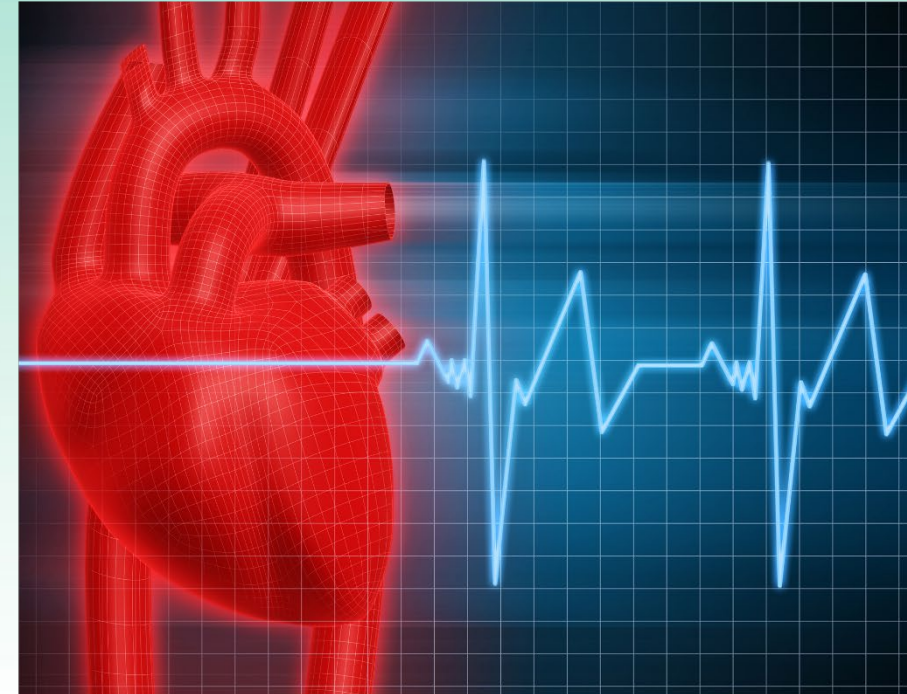
# Indications for Intubation

- **Absolute Indications**
  - Complete spinal cord injury above C5 level
  - Respiratory Distress
  - Hypoxemia despite adequate attempts at oxygenation
  - Severe Respiratory Acidosis
- **Relative Indications**
  - Complaint of Shortness of Breath
  - Increase work of breathing
  - Vital Capacity < 10 ml/kg or respiratory fatigue
- **Consideration Should be Given**
  - Need to "travel" remote from ED (i.e. MRI, transfer)



# Circulation

- Neurogenic shock
  - Injuries above T6
  - Hypotension
  - Bradycardia –treat symptomatic only
  - Warm and dry
  - Poikilothermic – keep warm
- Fluid resuscitation to correct hypovolemia
- Identify and control any source of bleeding
- Supplement with vasopressors





# Neurogenic Shock

Injury to T6 and above

Loss of sympathetic innervation

Increase in venous capacitance

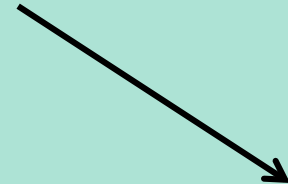
Bradycardia

Decrease in venous return

Hypotension

Decreased cardiac output

Decreased tissue perfusion





# Management

- Urine output may be decreased due to atonic bladder and urinary retention
- Foley insertion initially to avoid intermittent catheterization and monitor urine output







# Spinal Shock

## Deficit / Disability

- Spinal shock
  - Flaccid paralysis
  - Absence of cutaneous and/or proprioceptive sensation
  - Loss of autonomic function
  - Cessation of all reflex activity below the site of injury
- Identify level of injury





# Pain

- Frequent physical and verbal contact
- Explain all procedures to patient
- Patient-family contact as soon as possible
- Appropriate short-acting pain medication and sedatives
- Cautious use of sedation





# Communication

- Blink board
- Adapted call bell system
- Avoid clicking, provide a better option
- Speech and occupational therapy
- Prism glasses
- Setting limits/boundaries for behavior







# Management

## Special Treatment

- Hypothermia
  - Recommends 33°C intravascular cooling
  - Rapid application and close monitoring
  - Anecdotal papers
  - No peer reviewed/class I clinical research
  - Studies in progress

 **High dose  
methylprednisolone**





# Neuroprotective Agents

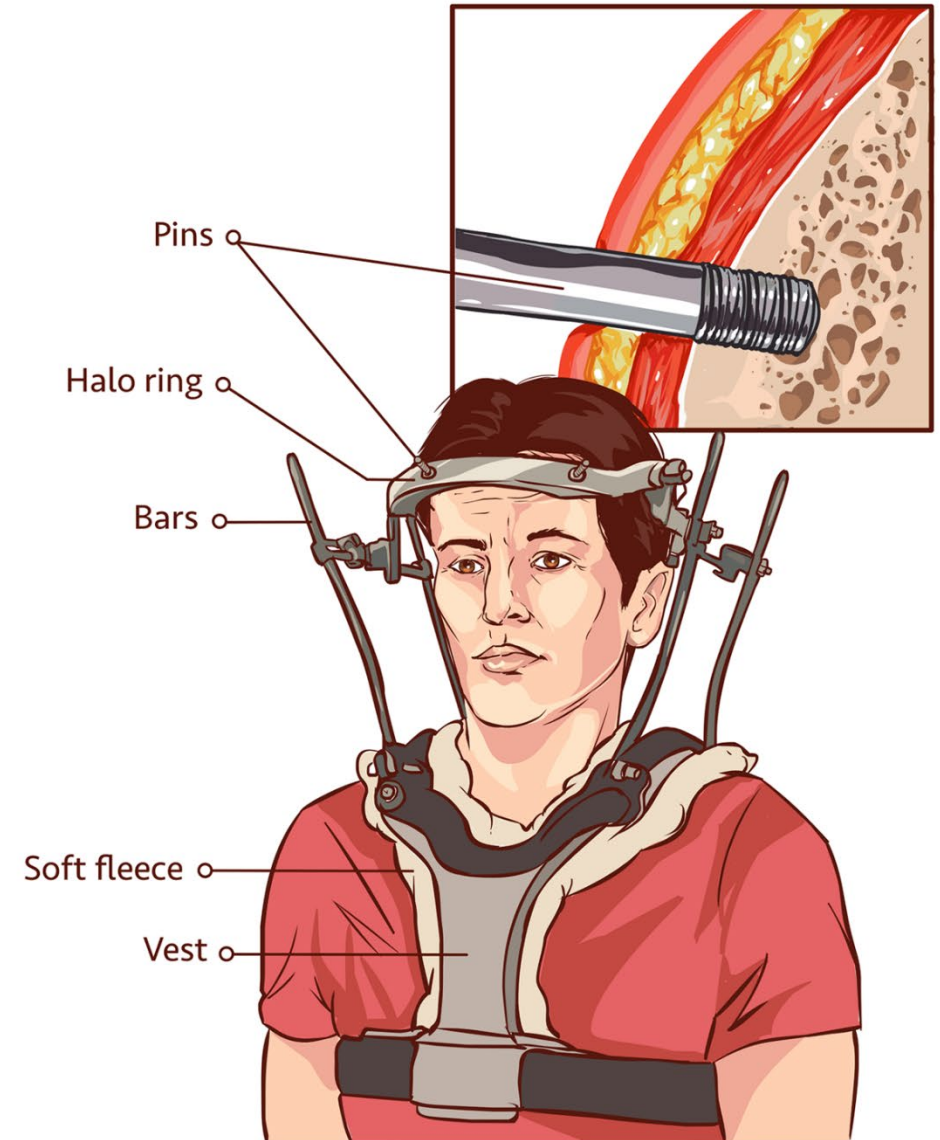
## Pharmacologic agents

- Lazaroids (21-aminosteroids)
- Glutamate receptor antagonists
- Antioxidants and free radical scavengers
- Arachidonic acid inhibitors
- More research is needed to validate effectiveness of neuroprotective therapy



# Non-Surgical Management

- **Reduction**
  - Cervical traction
    - Halo
    - Gardner-Wells tongs
  - Surgical
- **Stabilization**
  - Cervical collar – convert to padded collar as soon as possible
  - CTO or TLSO for low cervical, thoracic, lumbar injuries



**Surgical Stabilization with Halo**





# Surgical Management

- Decompression is the mainstay of treatment.
- Determined by:
  - Degree of deficit, location of injury, instability, cord impingement
  - Anterior vs. posterior decompression/both
- Emergent
  - Reserved for neurologic deterioration when evidence of cord compression is present
- Somatosensory evoked potentials (SSEP) – during procedure to monitor changes
  - Limited to ascending sensory tracts, especially dorsal columns

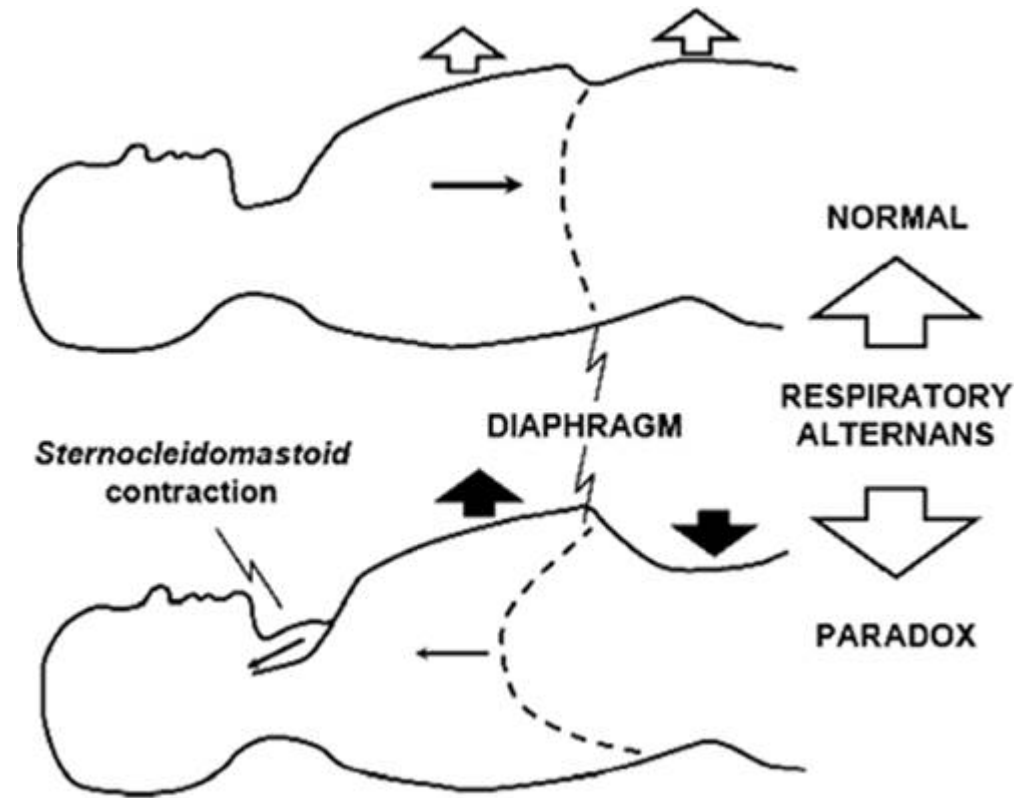


# Prevention of Complications



# Respiratory

- Most common complication
- Monitor breathing effectiveness
- Incentive spirometer
- Adjunctive treatments (i.e. postural drainage, suctioning, intrapulmonary percussive ventilation)
- Ventilator Bundle - Institute for Healthcare Improvement







# Respiratory

## Non-ventilated patients

- Pulmonary function tests
- Incentive Spirometry
- End Tidal CO<sub>2</sub> monitoring
- Non-invasive ventilation (CPAP, BiPAP)
- Abdominal binder
- Early OOB/mobilization







# Respiratory

**Mechanical Ventilation**

**Early intubation to prevent hypoxia and fatigue**

**C1-4 injuries may require tracheostomy and home ventilation training**

**Assistive (Quad) cough technique**

**Communication tools**

**Bronchoscopy**

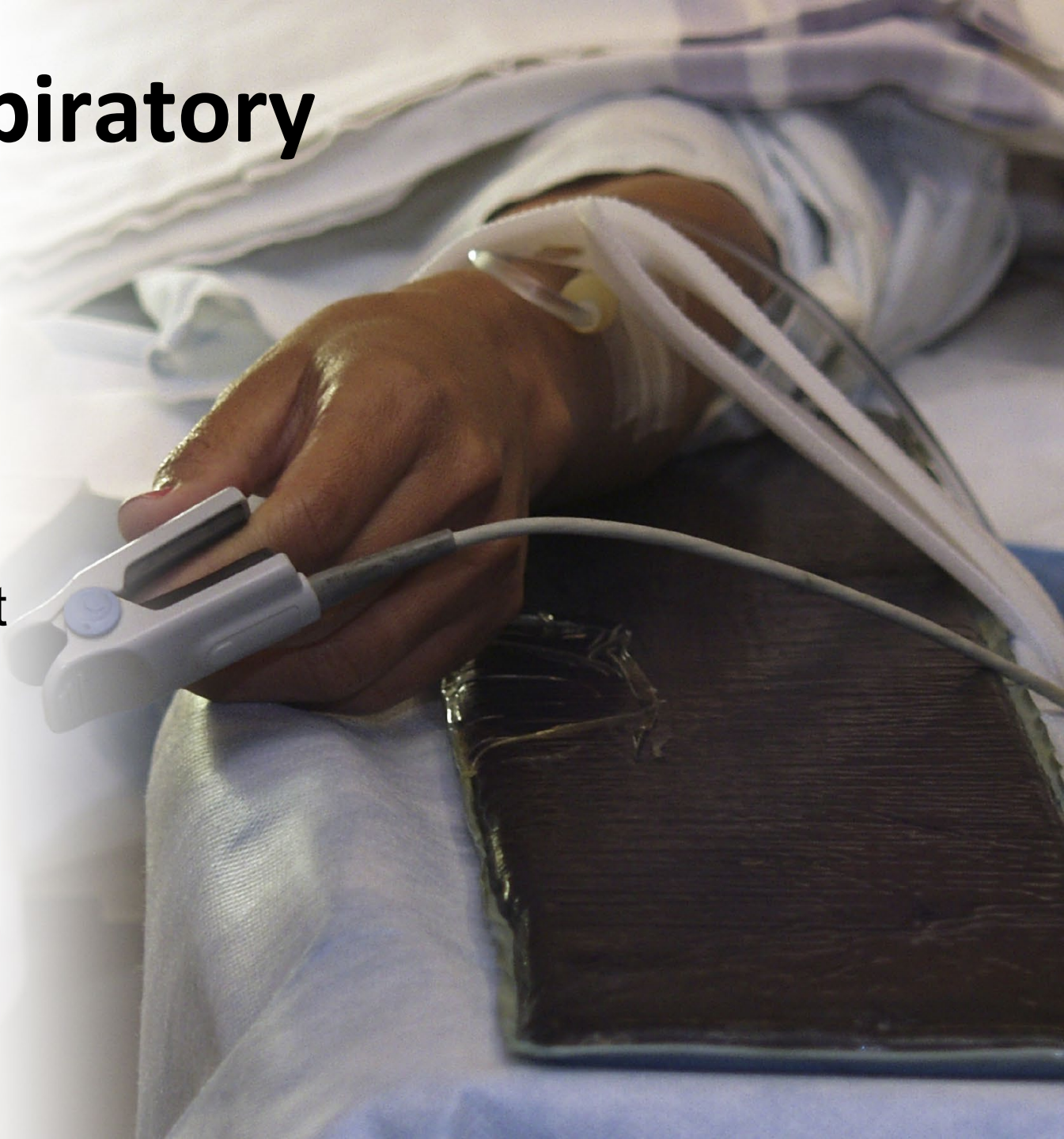




# Respiratory

## Pulmonary management

- Weaning parameters
- Monitor SpO<sub>2</sub> and ABGs
- Routine CXR
- Aggressive pulmonary toilet
  - Postural drainage (PD)
  - Chest physiotherapy (CPT)
- Suctioning





# Cardiovascular

- Neurogenic shock
- IV fluids to correct hypovolemia
- Vasopressors
- Maintain a MAP of 85-90 for 7 days post injury in order to maximize spinal cord perfusion
- Atropine or pacing **ONLY** when bradycardia symptomatic







# Cardiovascular

## Orthostatic hypotension

- Decreased BP, possibly increased heart rate, dizziness or lightheadedness, blurred vision, loss of consciousness
- Provide physical support with hose, abdominal binder; salt tablets; Florinef; sympathomimetics
- Slowly raise the head of the bed for mobilization
- Turn slowly, prone to vasovagal response
- Follow ACLS guidelines for symptomatic bradycardia, cardiac arrest





# Cardiovascular

## Poikilothermia

- Inability to shiver/sweat and adjust body temperature
- Keep patient warm
- Warm the environment
- Monitor skin to prevent burns or frostbite from exposure



# Gastrointestinal

- Ileus
- Gastric/intestinal ulcers
- Pancreas dysfunction
- Nutritional deficiencies
- Constipation/impaction
- Cholecystitis







# Gastrointestinal

- Abdominal distention
  - Nasogastric tube to decompress stomach
  - Monitor bowel sounds
  - Monitor N/G output for bleeding
  - Gastric prophylaxis:
    - Histamine blockers, proton-pump inhibitors, antacids
- Bowel routine
  - Stool softeners, suppositories; high fiber diet
  - Digital stimulation, fluids, mobilization



# Gastrointestinal

## Nutrition

- Early enteral nutrition
- PO or tube feeding if ventilated
- Transpyloric tube if slow gastric emptying
- Hypermetabolic rate
  - Feed as with any critically injured patient







# Venous Thromboembolism

- Slightly higher risk the first 2-3 months post injury
- Duplex ultrasonography evaluation
- Prevention (x 3 months)
  - LMWH
  - Apply sequential compression devices
  - Vena cava filter (in patients who cannot be anti-coagulated or have failed anti-coagulation)
- Monitor for signs and symptoms
- Early mobilization, hydration



An anatomical diagram of the human urinary system. The bladder is shown as a pink, oval-shaped organ in the center of the pelvic region. Two red lines representing the ureters extend upwards from the bladder towards the kidneys. A red line representing the urethra extends downwards from the bladder through the urethral opening. The background is a blue-tinted illustration of the human torso and pelvic bones.

# Neurogenic Bladder

- Involuntary contraction
- Reflex initiated voiding when bladder full
- Fluid restriction
- Transition to straight catheterization, condom catheter, or suprapubic tube
- Palpate for fullness (approx. 500 - 600ml/ 4 – 6 hr)





# Aneurogenic Bladder

- **Atonic or denervated bladder**
  - Urinary retention
  - Prone to incontinence/skin issues
  - Condom catheters, incontinence pads, urinary conduit
- **Detrusor Sphincter Dyssynergia (DSD)**
  - Loss of coordination between bladder and external sphincter
  - Results in elevated voiding pressures
  - Pharmacologic management
  - Surgical intervention (sphincterotomy)



# Urinary Tract Infection

- **Signs and symptoms**
  - Fever, spontaneous voiding between catheterizations, Autonomic Dysreflexia, hematuria, cloudy foul-smelling urine, vague abdominal discomfort, pyuria
- **Prevention**
  - Remove indwelling catheter as soon as clinically possible, intermittent cath, hydration





# Renal Calculi

- Chronic bacteriuria and sediment, long-term indwelling catheters, urinary stasis, chronic calcium loss
- Signs and symptoms – persistent UTI, hematuria, unexplained Autonomic Dysreflexia
- KUB x-ray, IVP with cystogram, passage of stone
- Interventions - increased fluid intake, dietary modifications, lithotripsy







# Skin Breakdown


- Immobility, loss of sensation, pressure
- Dampness from incontinence
- PREVENTION – frequent turning, specialty beds, remove backboard ASAP; proper fitting braces
- Nutrition, mobilization, cushions, massage
- Early wound care specialist
- Surgery if deep
- Can cause delays in stabilization, rehabilitation





# Musculoskeletal

## Spasticity

- Flexor, extensor, or combination
  - Reduces venous pooling, stabilizes thorax
  - Associated with chronic pain, sleep disturbances, contractures, heterotrophic ossification, skin breakdown
  - ROM, positioning, weight-bearing, splinting, pharmacologic management, surgery- neural severing (permanent)
- 





# Musculoskeletal

## Contractures

- Imbalance of muscle innervation
- Certain muscle groups become stronger than the opposing muscle
- Can lead to loss of function and functional independence
- PREVENTION – aggressive ROM, mobilization, PT/OT, splinting, positioning, serial casting, anti-spasmodics
- Rehabilitation Services consults





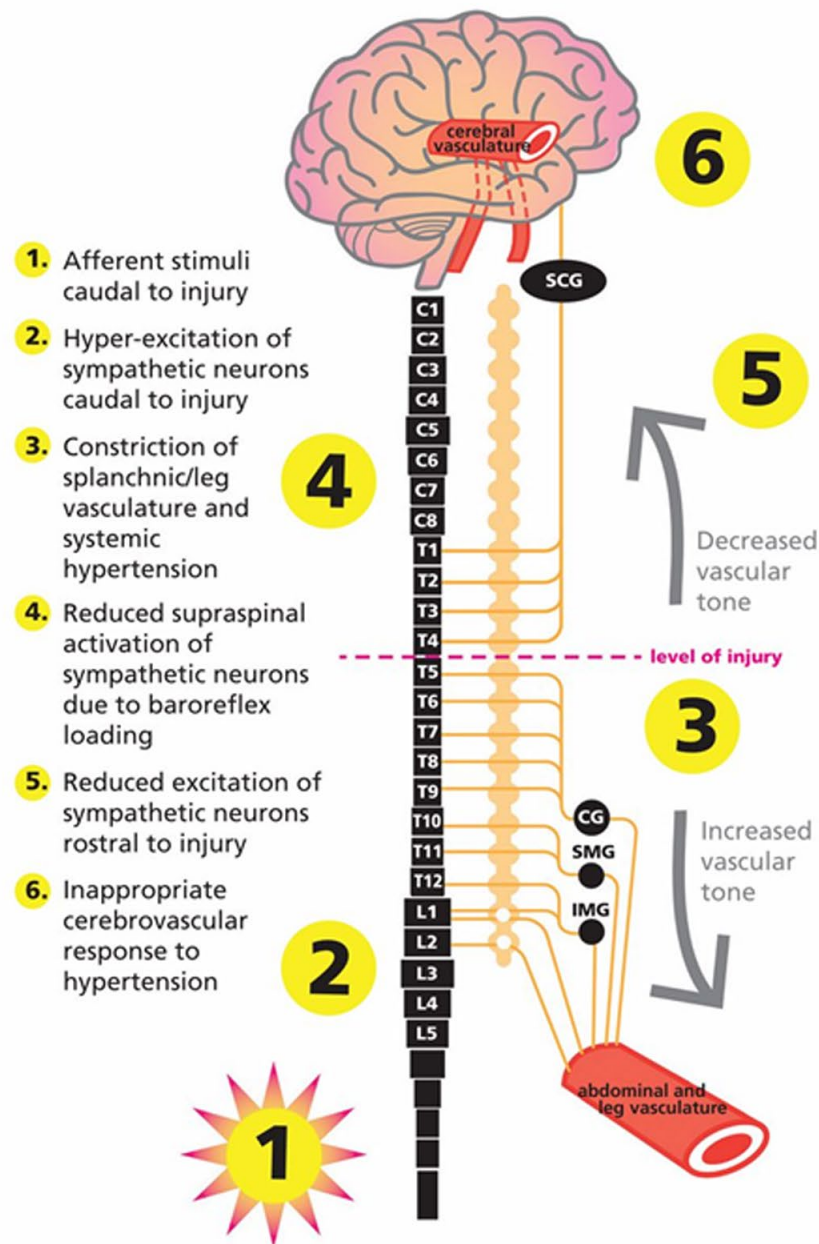
# Heterotopic Ossification

- Ectopic bone deposited within connective tissue
- Develops below spinal lesion
- Occurs more often with complete injuries and spasticity





# Autonomic Dysreflexia







# Autonomic Dysreflexia

- Uncontrolled elevation of BP 20-30 mmHg above patient's baseline
- May be accompanied by bradycardia
- Below injury – severe vasoconstriction
  - Pallor, chills, goose bumps, cool skin
- Blood shunted into nonconstricted vessels above lesion, causing hypertension
  - Flushing, congestion, headache
- If untreated can lead to myocardial infarction, stroke





# Autonomic Dysreflexia

- Sit patient upright to produce orthostatic hypotension
- Monitor BP every 5 minutes
- Monitor neurologic status (GCS)
- Eliminate the offending stimulus
  - Empty bladder, bowel; identify skin lesion
- Loosen clothing
- Administer rapid onset, short acting anti-hypertensives if needed
- Education – family and patient





# Psychologic

## Pain and Depression

- Nociceptive – noxious stimuli to normally innervated parts
- Neurogenic – nerve tissue injury in CNS or PNS
- Strong relationship between pain and anxiety/depression
- Counseling, ROM, pharmacologic treatment, TENS



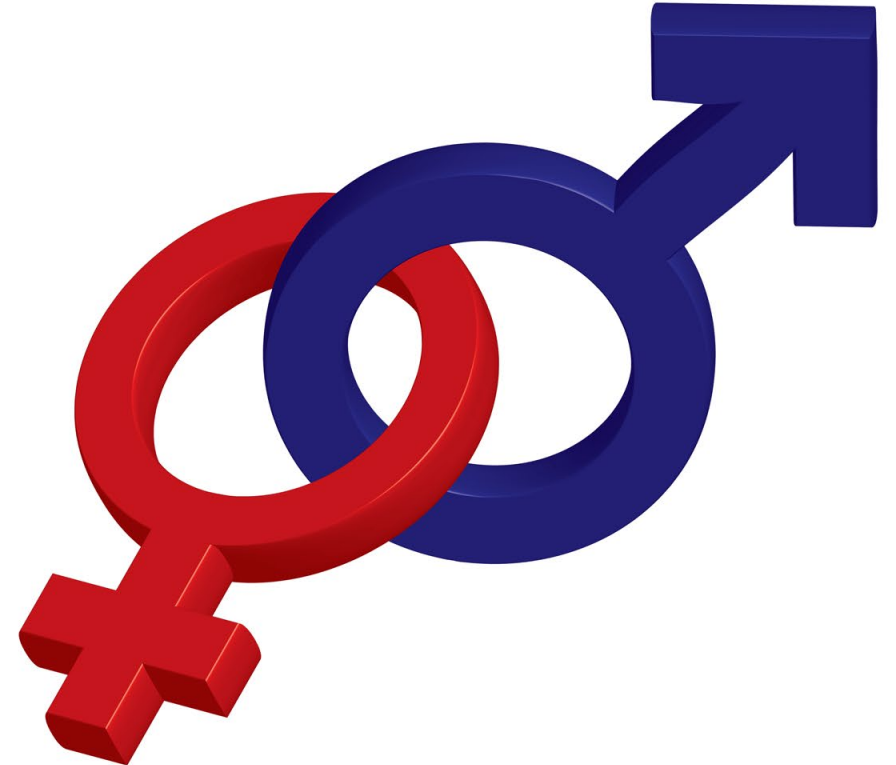




# Sexuality

## Male sexuality

- Erection – parasympathetic
- Requires intact sacral reflexes, short-lived
  - Technical aides, pharmacology, prosthesis
- Ejaculation – sympathetic
  - Intrathecal injection, electroejaculation, vibroejaculation
- Fertility – decreased sperm motility and quality
  - Serial ejaculation, in vitro fertilization







# Sexuality

## Female

- Lack innervation to pelvic floor
- Maintain reflex lubrication/congestion
- Loss psychogenic/fantasy response
- Fertility normal
  - Pregnancy – loss of sensation, increased BP, may precipitate AD
  - Decreased respiratory excursion
  - Alter GI/GU management







# Rehabilitation

- Begin as soon as medically stable
- Mobility
  - Tendon transfer
  - Functional electrical stimulation
  - Lower level of injury, more functional
- Bowel and Bladder Management
- Prevention of complications
- Social services, community resources



# Summary

- Spinal cord injury occurrence is decreased with safety equipment use.
- Prevent secondary injury to result in optimal neurologic recovery.
- Spinal column fractures can occur with or without long term effects.
- Spinal cord injury requires diligence in complication prevention.