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Spinal Column and Spinal Cord Injuries

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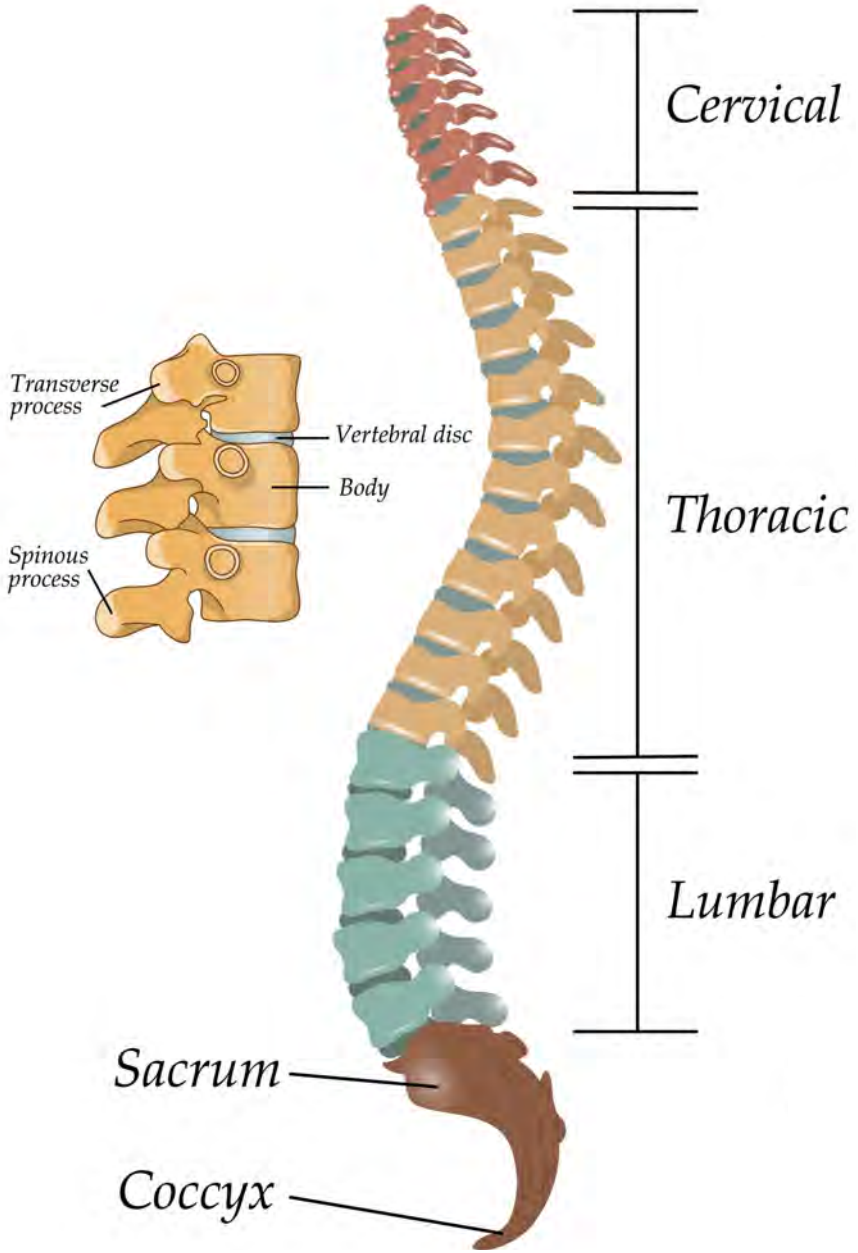
Objectives

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

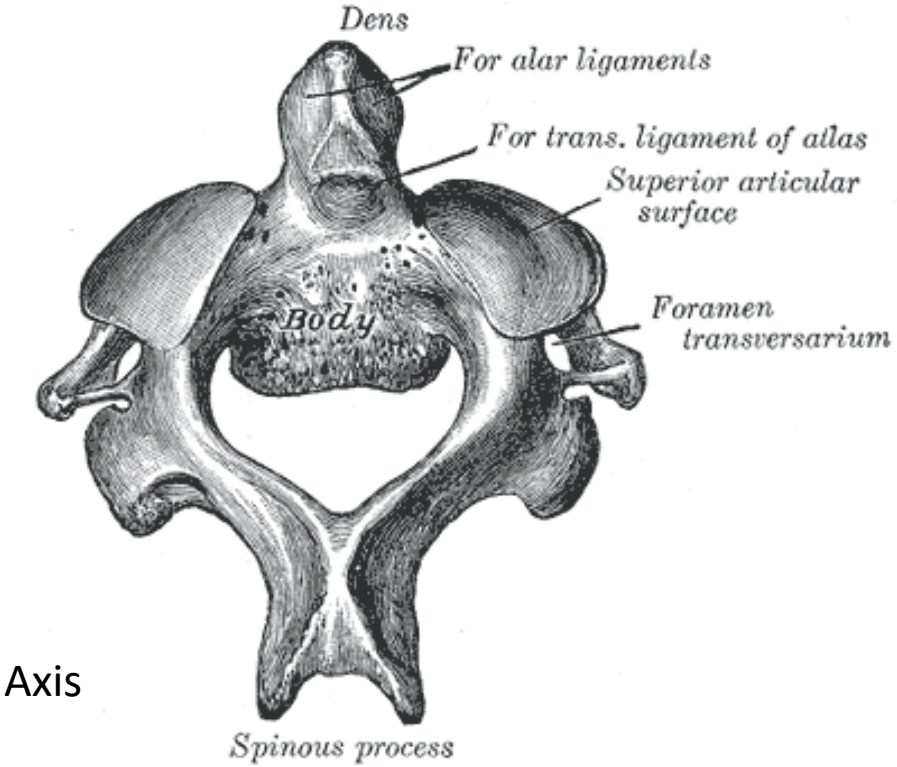
- Approximately 17,810 new cases per year
- Average age at injury is 43 years
- Male - 78%
- Incidence:
  - Non-Hispanic whites: 59%
  - Non-Hispanic blacks: 24%
  - Hispanic origin: 13%
- Most common causes – Motor Vehicle Crashes (38.6%), Falls (32.2%) and Violence (14%)
- Bimodal distribution of occurrence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



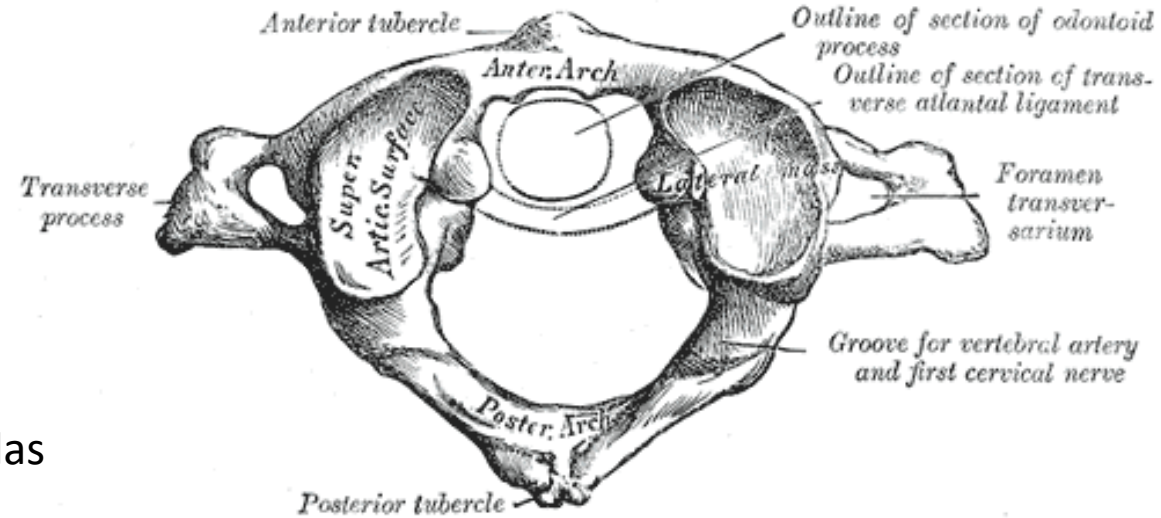
Anatomy and Physiology

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

Cervical Vertebrae

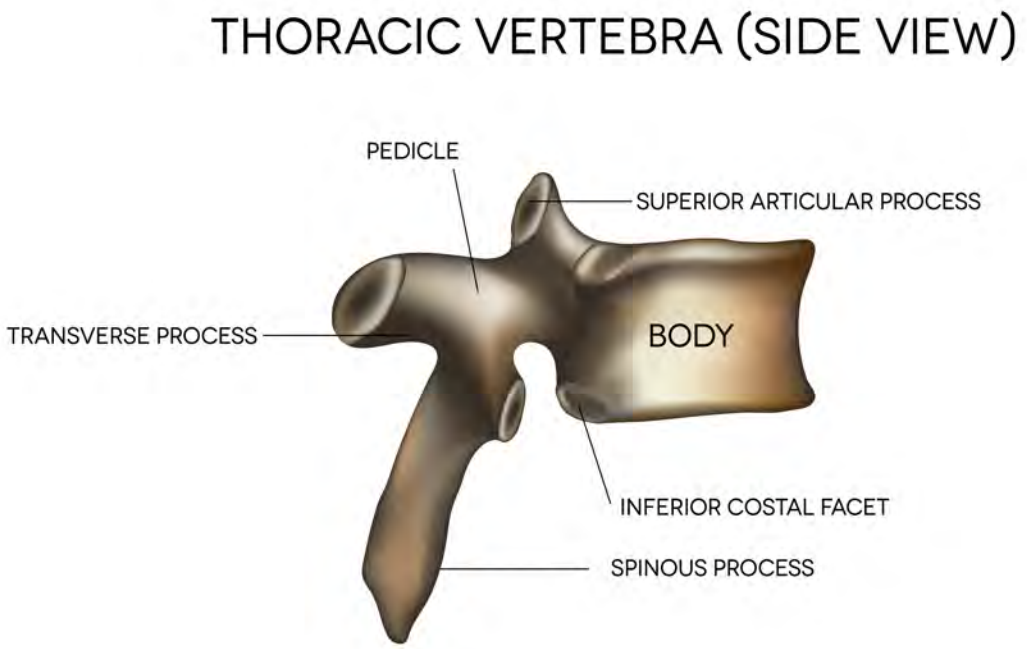


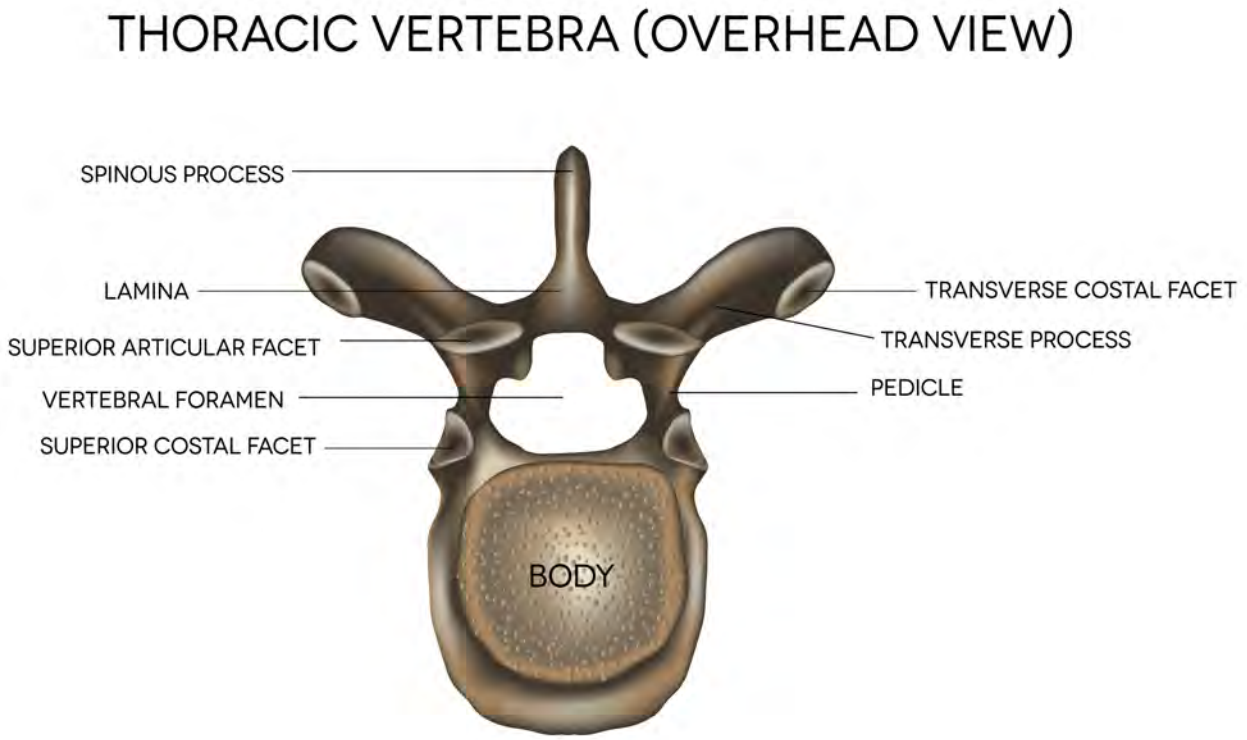
C2 Axis



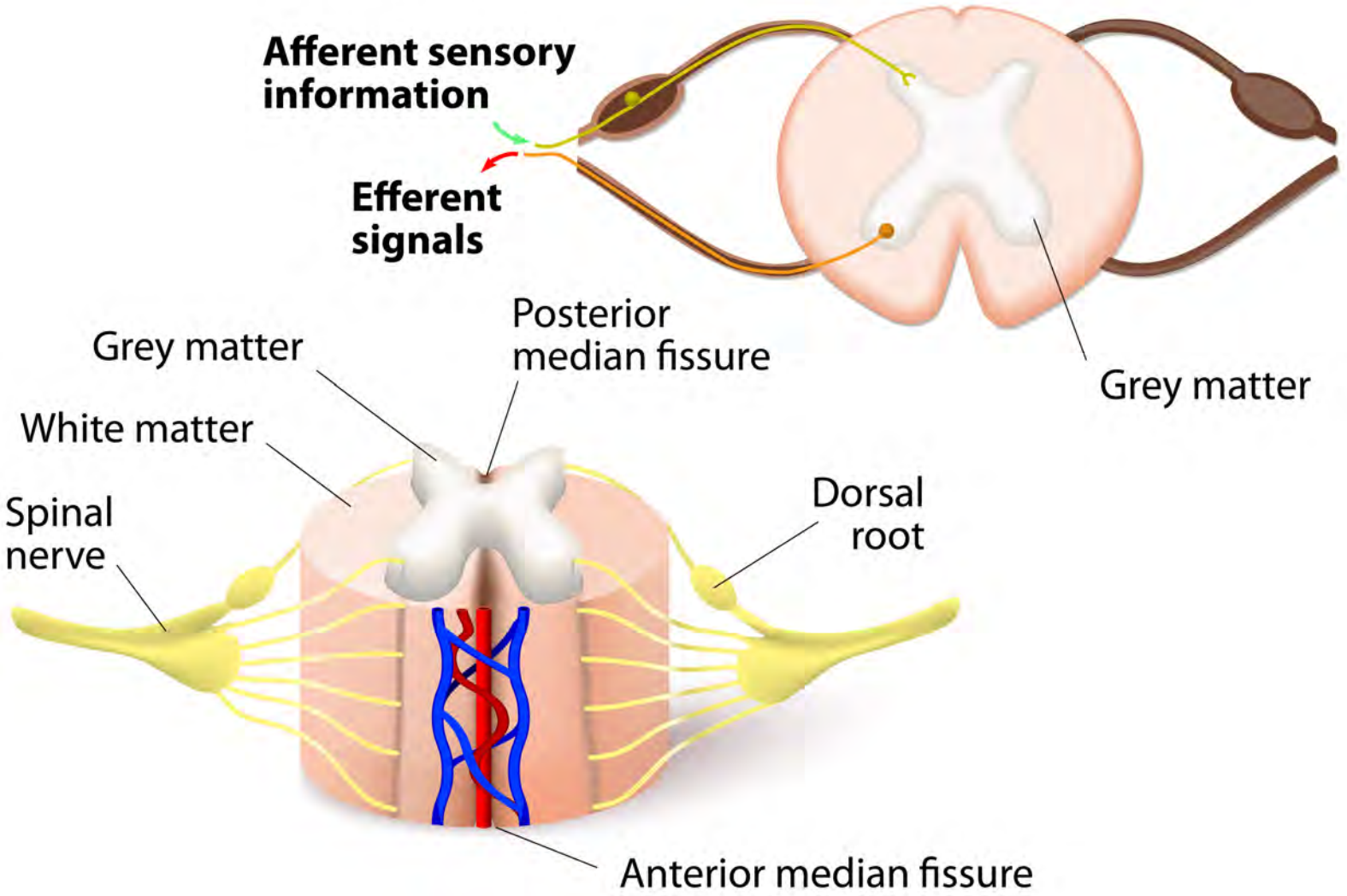
C1 Atlas

Thoracic Vertebra



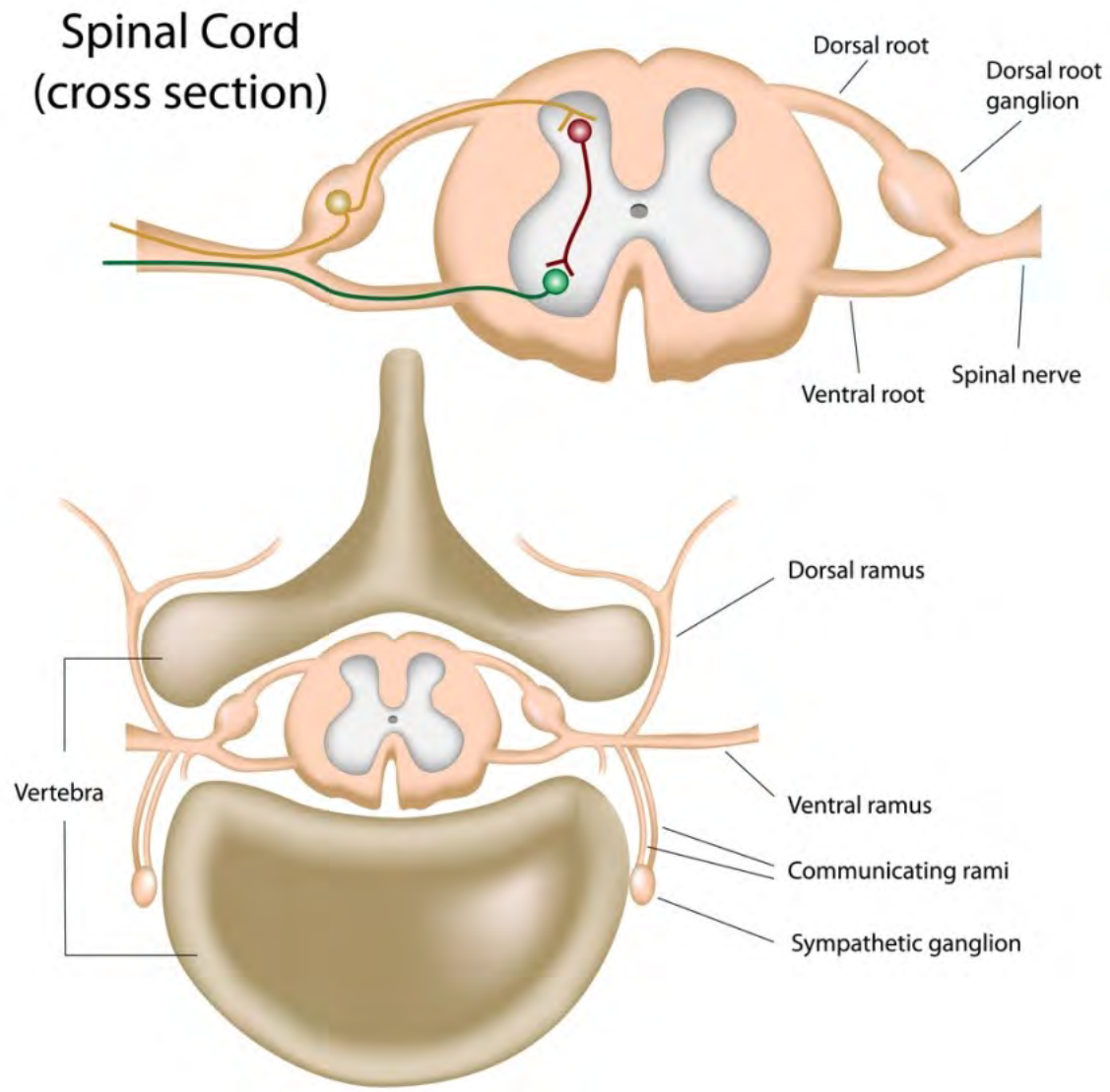


Spinal Cord


Afferent sensory information
Efferent signals
Grey matter
Posterior median fissure
Grey matter
White matter
Spinal nerve
Dorsal root
Anterior median fissure

Spinal Cord

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

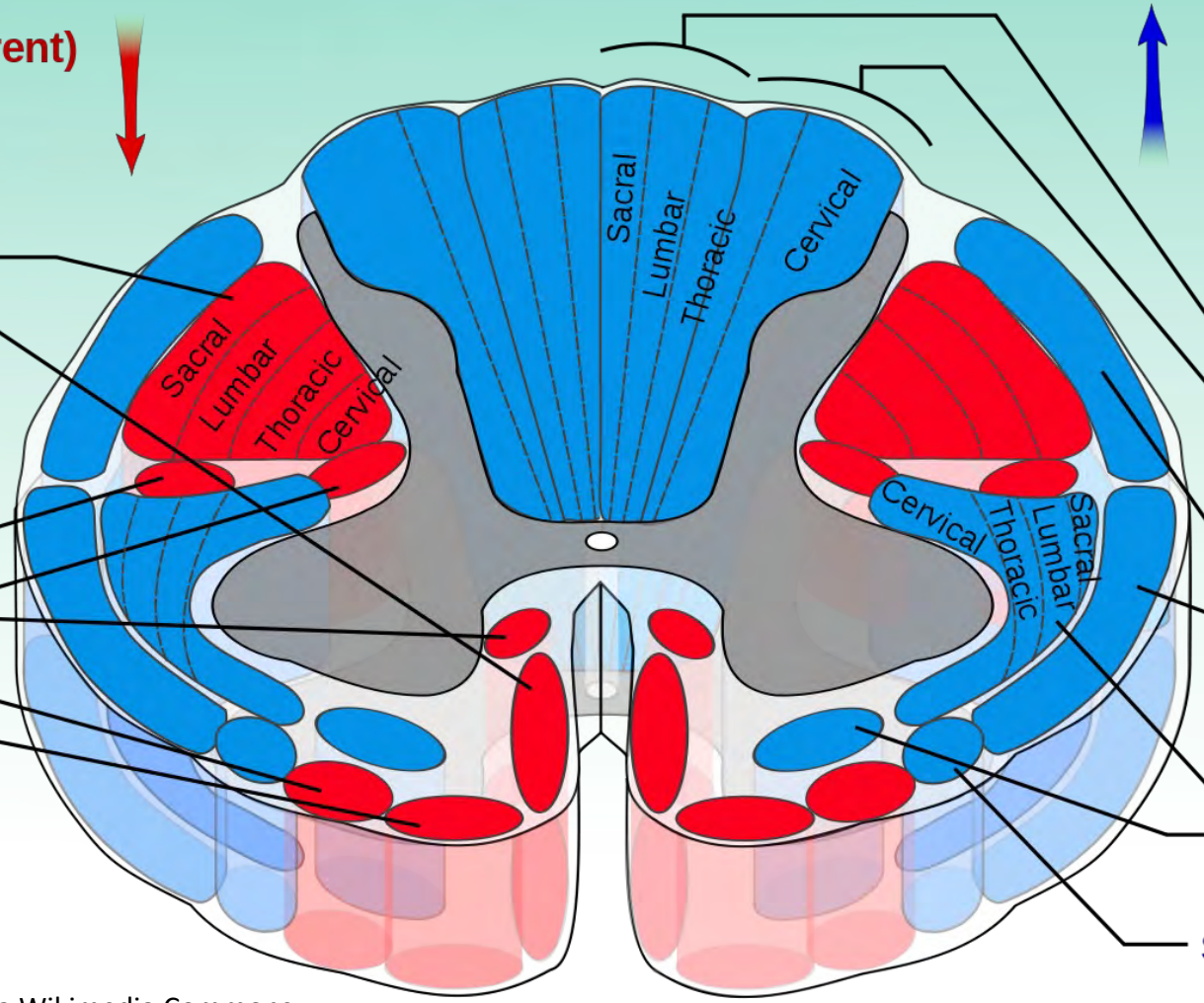


Spinal Cord

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

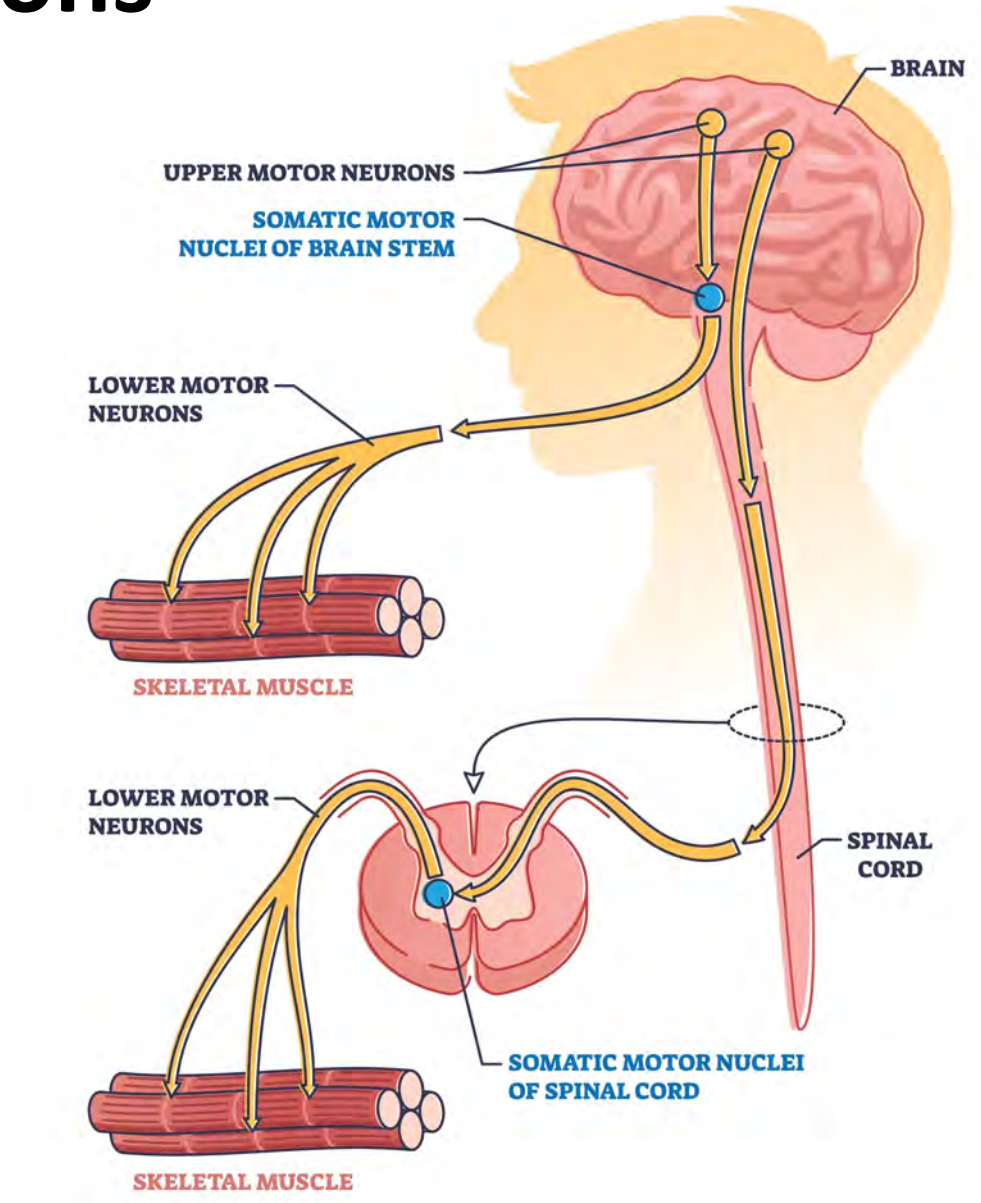
Motor Neurons

Upper motor neuron (UMN)

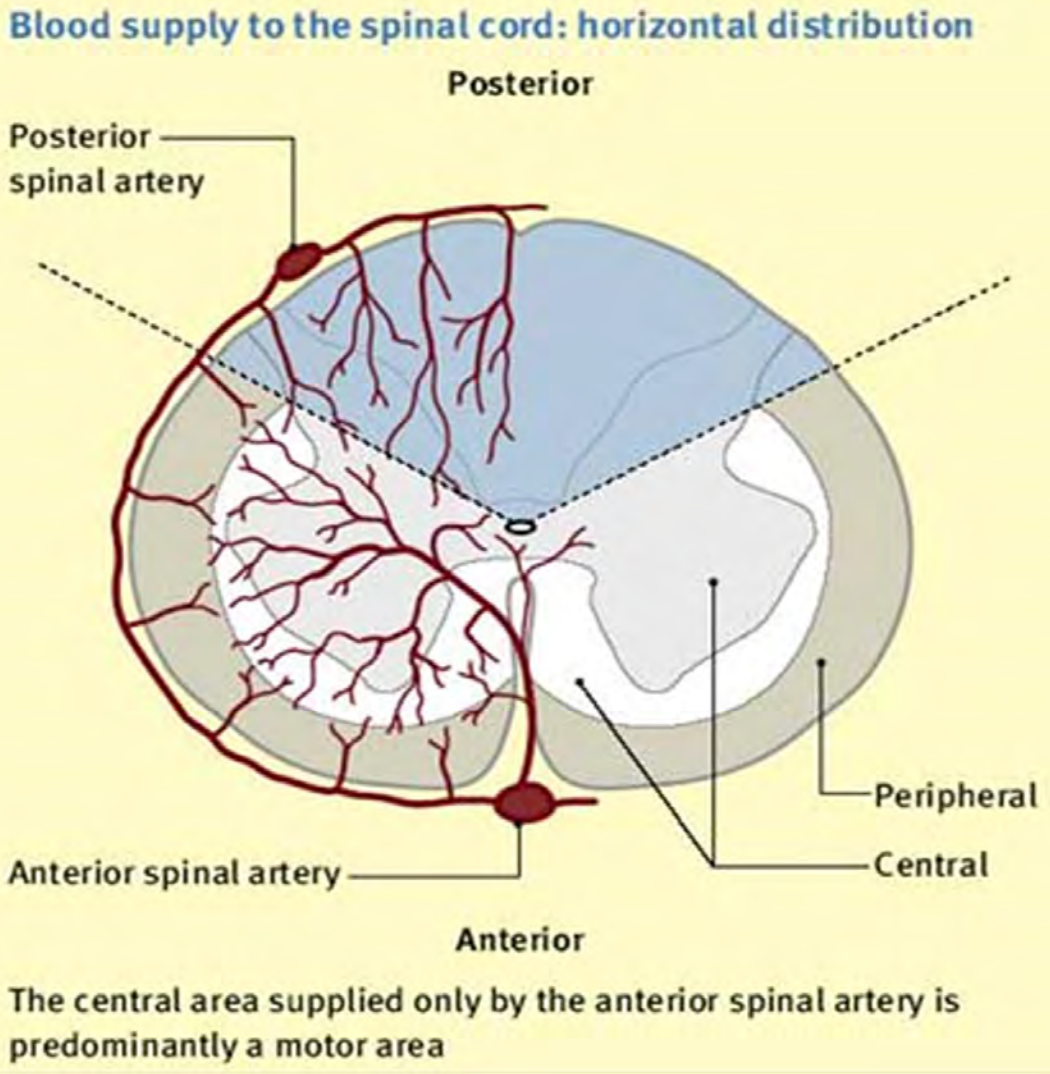
- Project from the motor strip in the cerebral cortex
- Fully contained in the CNS
- Injury = paralysis, hypertonicity, hyperreflexia

Lower motor neuron (LMN)

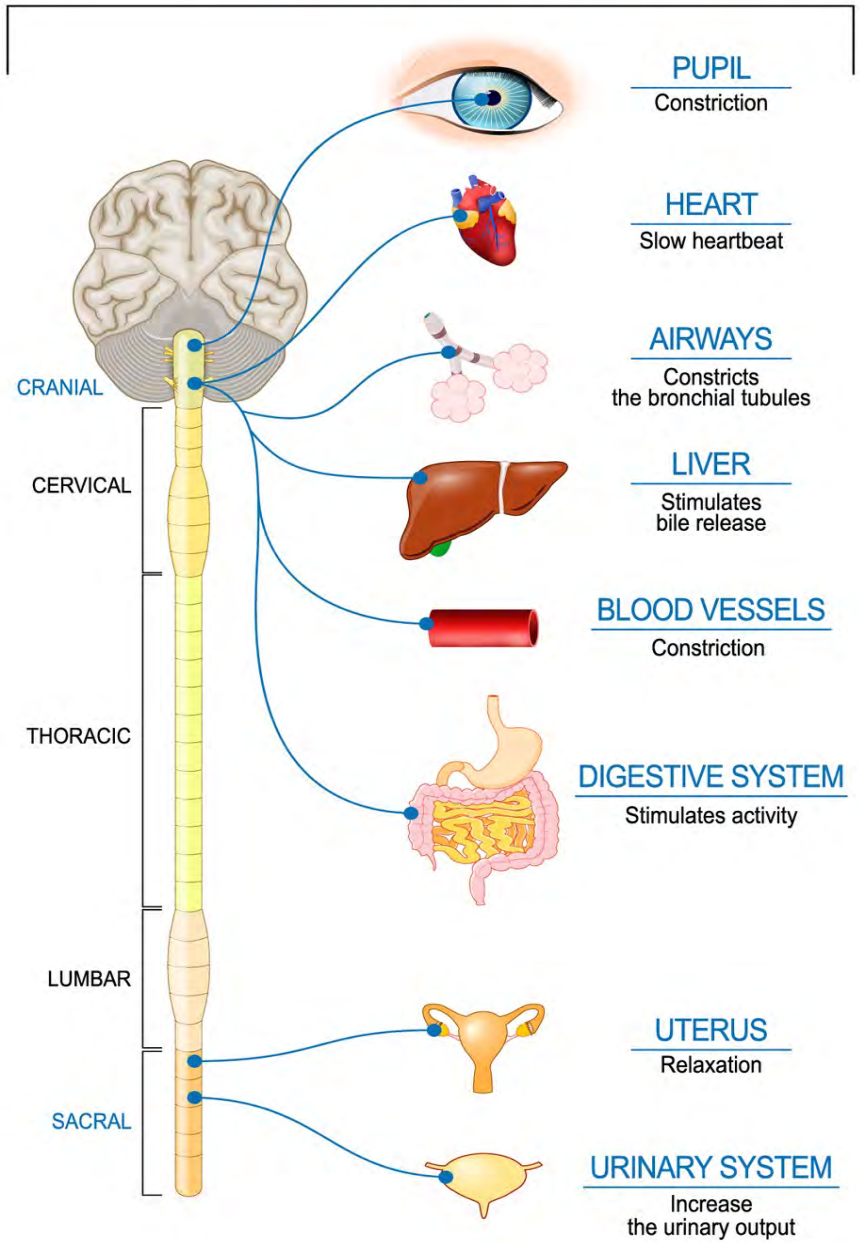
- Located in the ventral horn of the spinal cord
- Injury = flaccidity, hyporeflexia, fasciculations



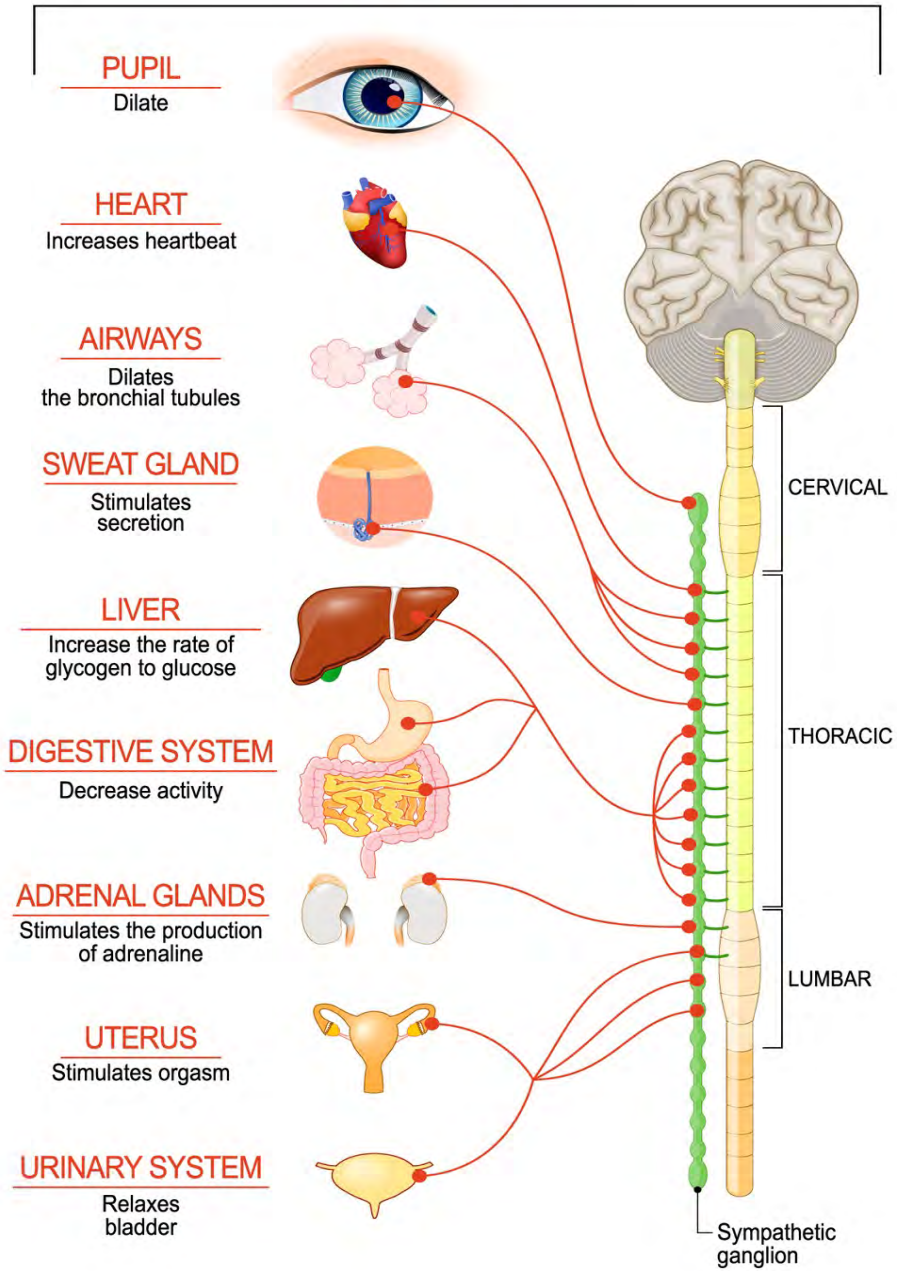
Blood Supply Spinal Cord



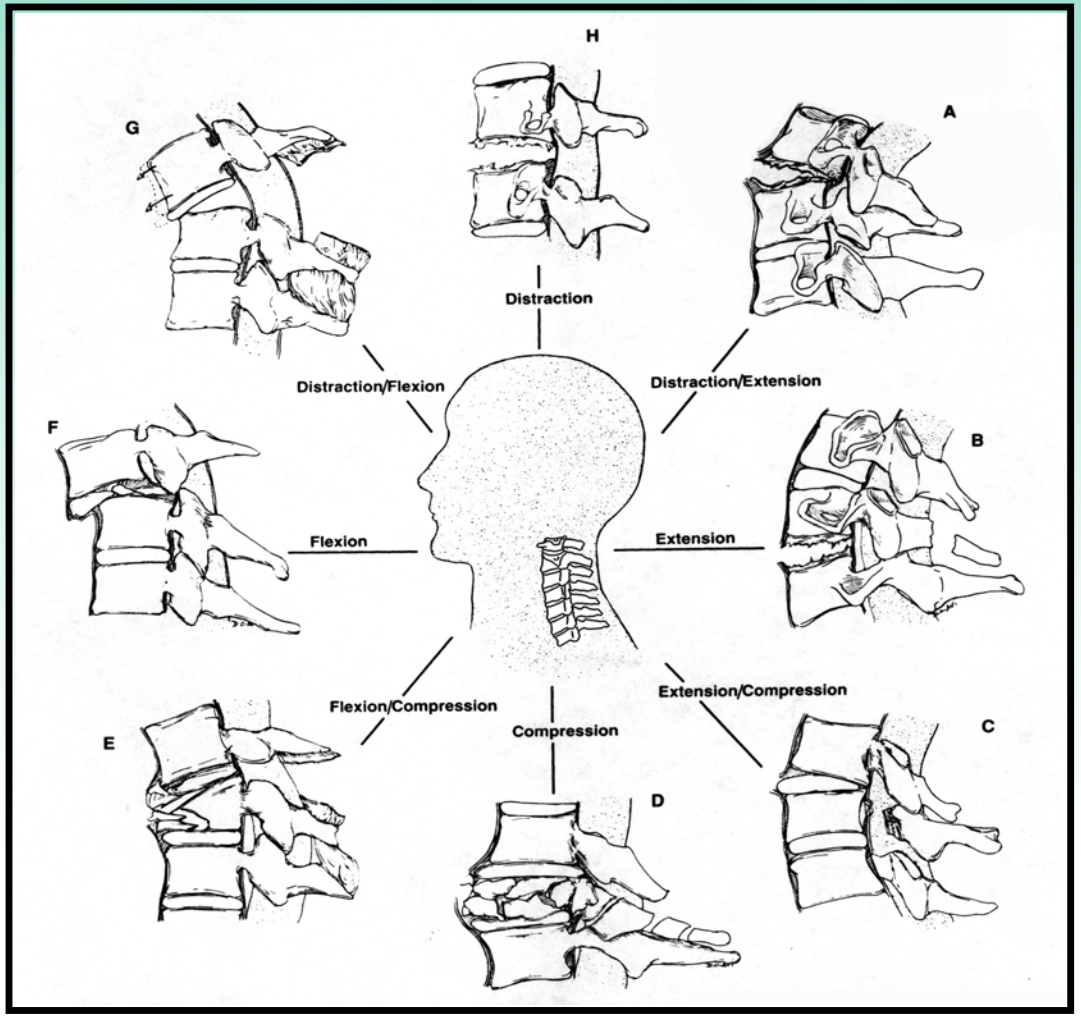
Parasympathetic



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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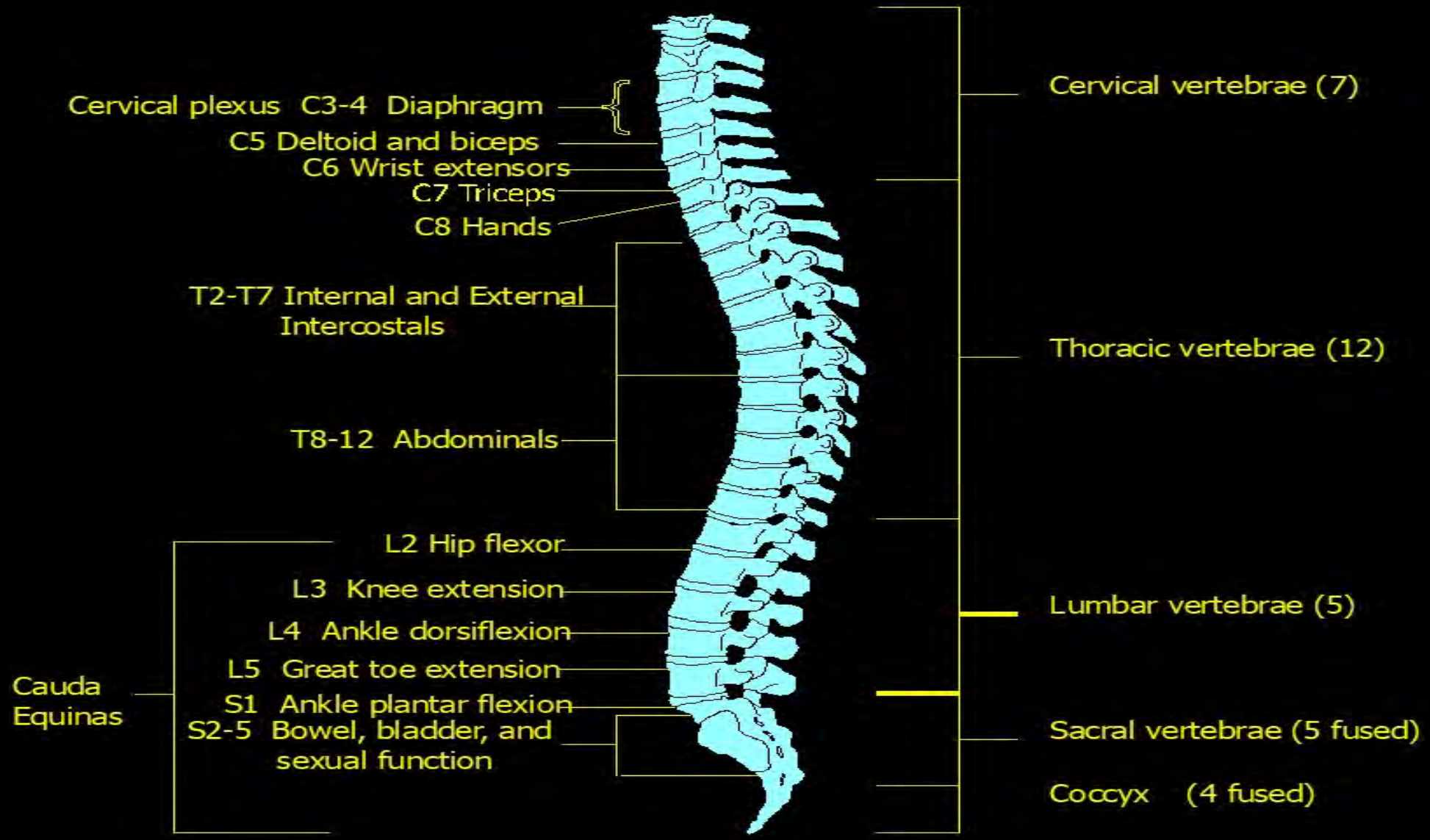
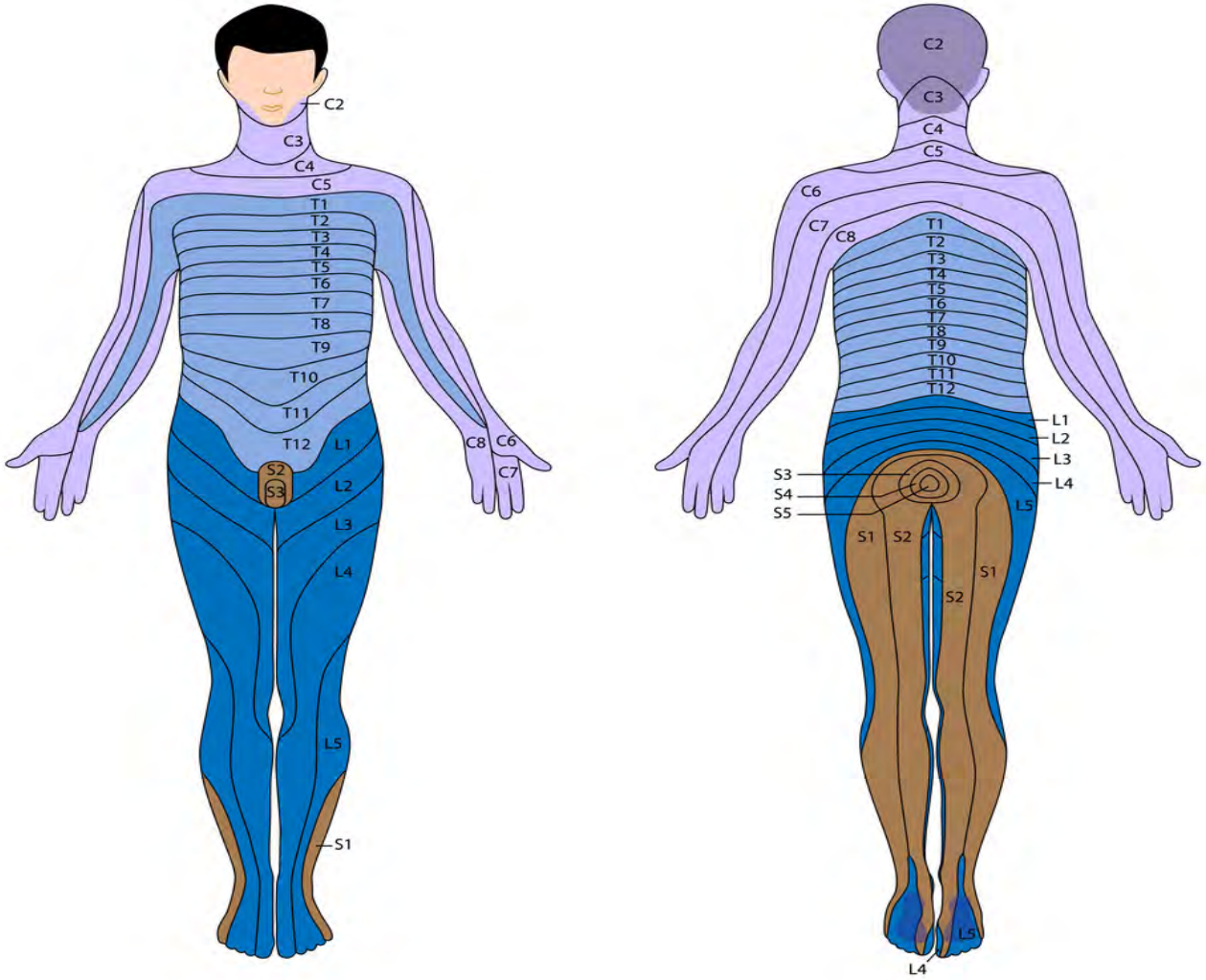
Motor Assessment



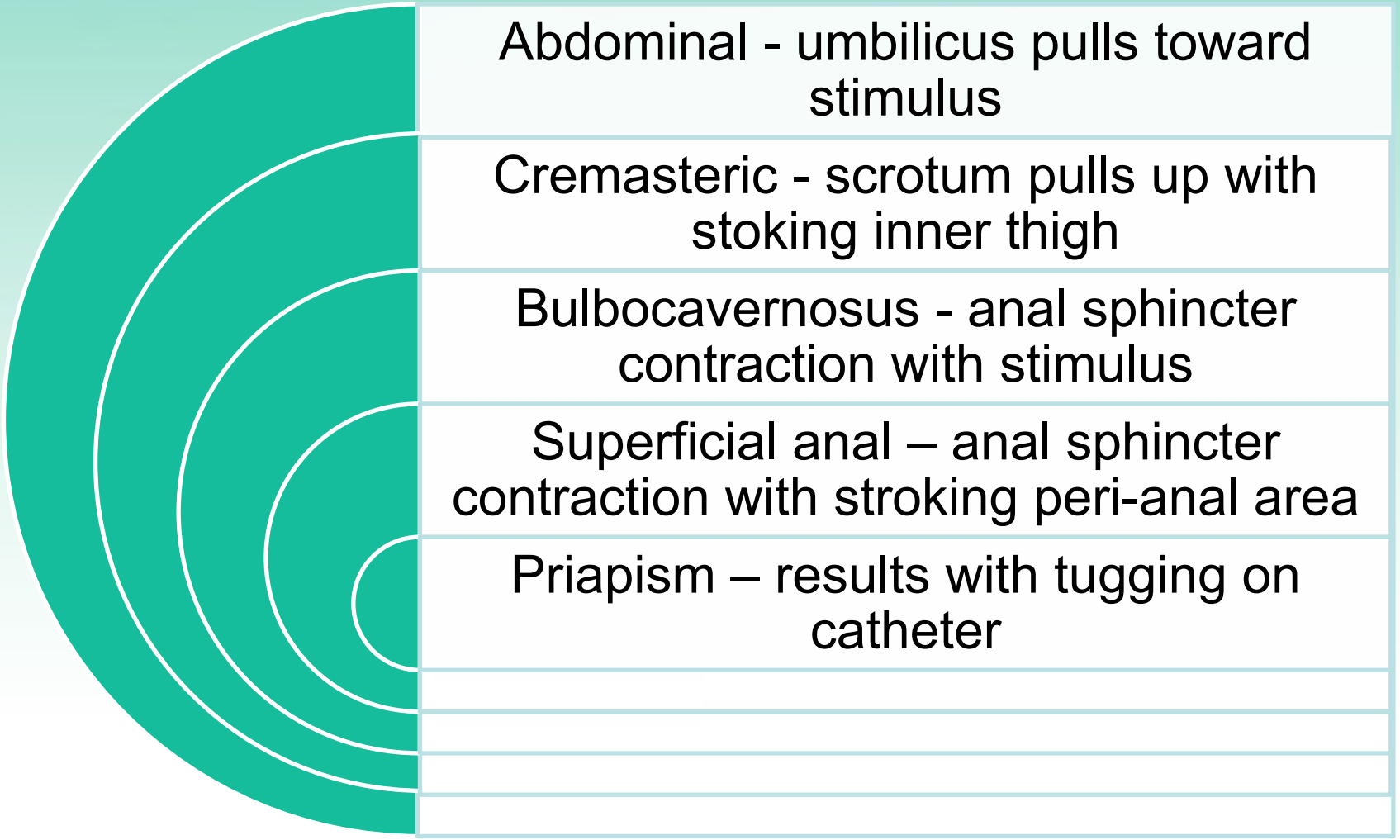
Dermatomes Sensory Assessment



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



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 ≥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

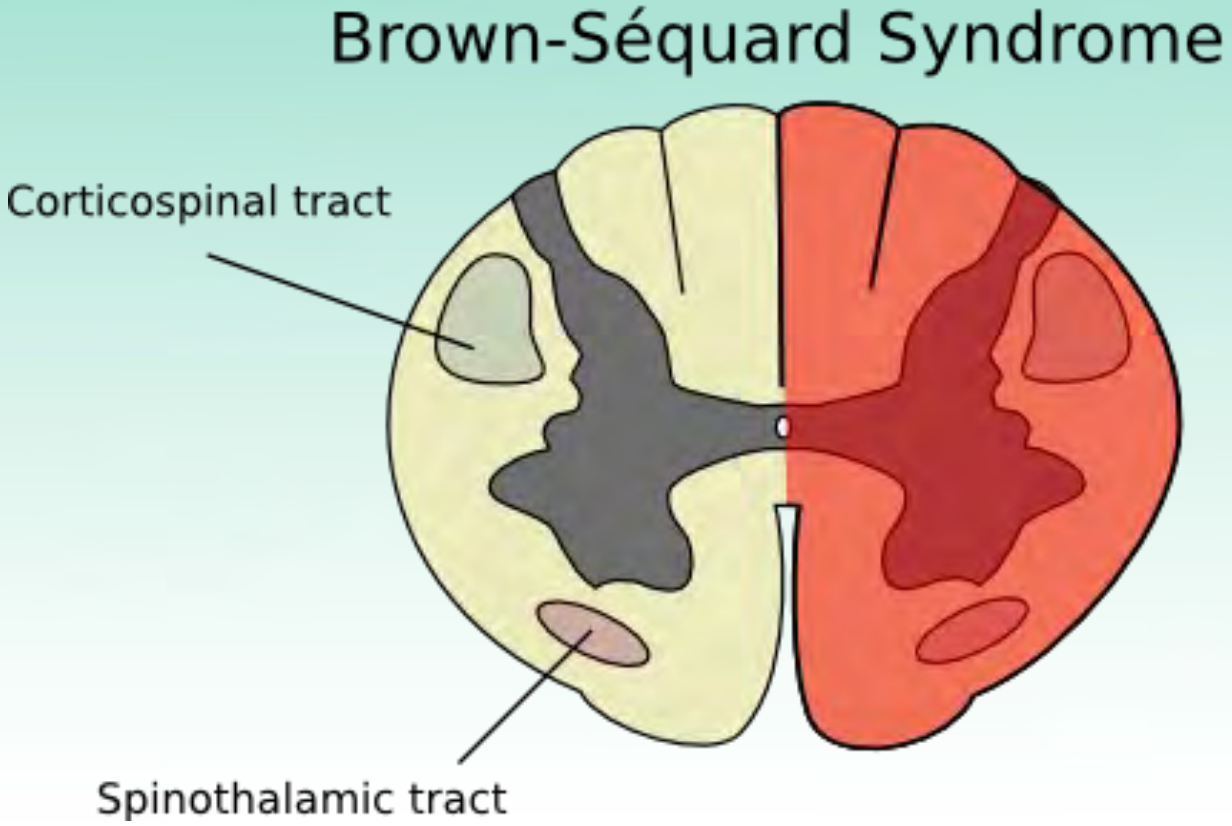
- Primarily a hyperflexion mechanism
- Anterior segment of spinal cord controls motor function below the injury

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



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

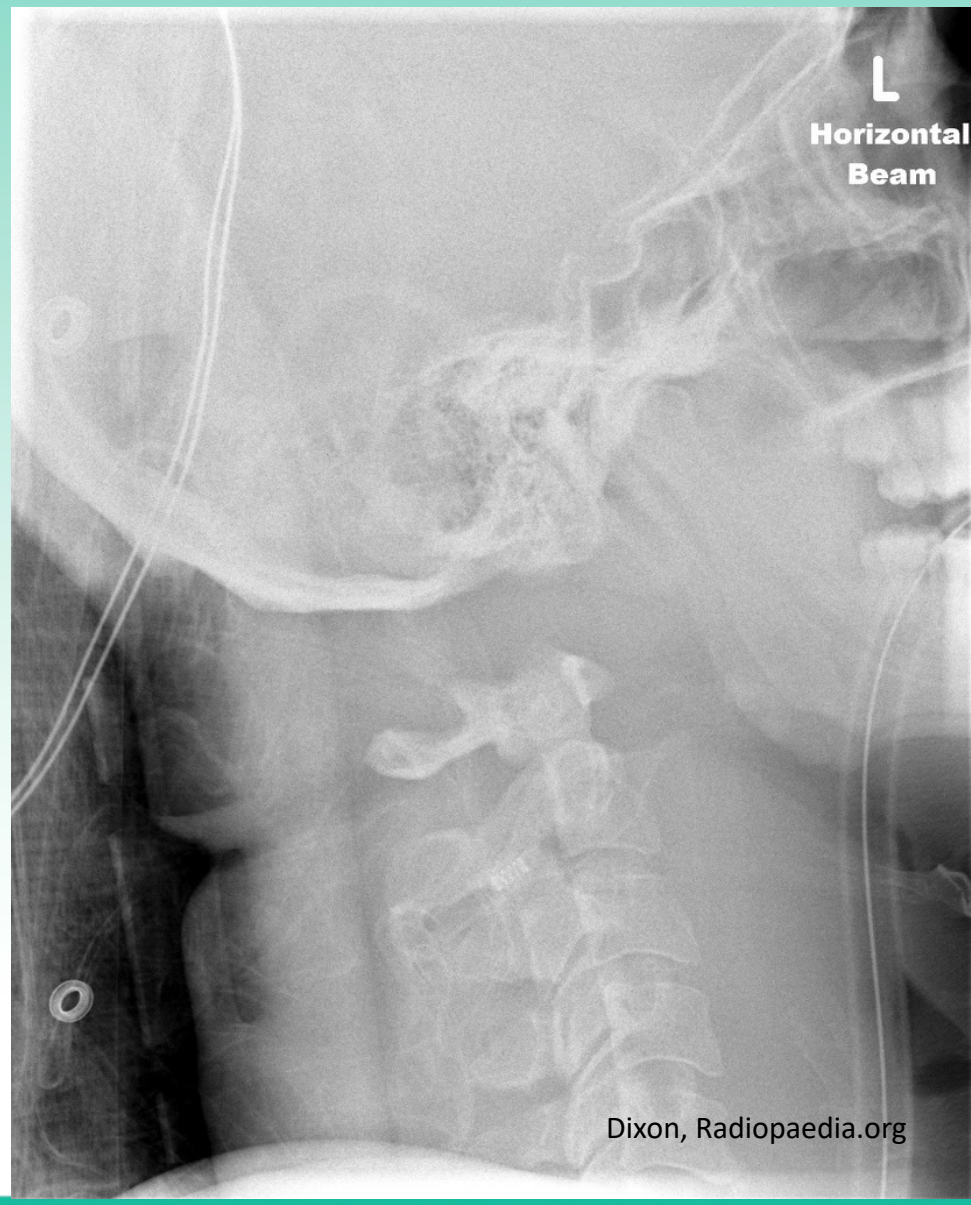
- Awake, alert, and oriented
- NO distracting injuries
- NO drugs or alcohol that alter experience
- NO pain or tenderness
- NO focal neurologic deficits

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



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Fractures-Dislocations

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

Fractures-Dislocations

- Compression
- Burst
- Chance

Dixon, Radiopaedia.org

SCIWORA

Spinal Cord Injury without Radiographic Abnormality

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

Management

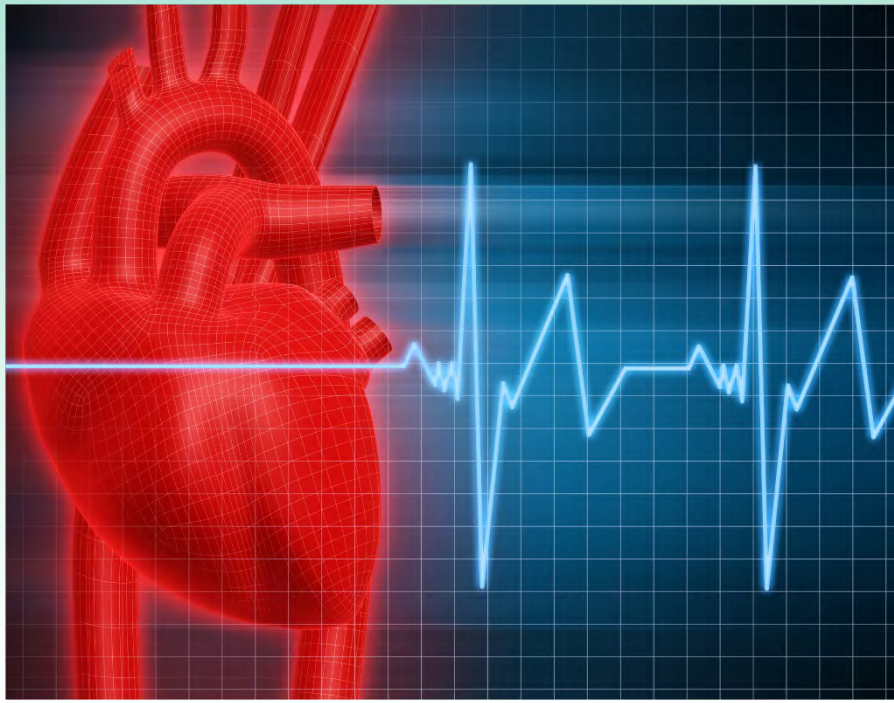
- **Airway**
  - C1-4 injuries require definitive airway
  - Injuries below C4 may also require airway due to:
    - Work of breathing
    - Weak thoracic musculature
- **Breathing**
  - Adequacy of respirations
    - SpO2
    - Tidal volume
    - Effort
    - Pattern

Indications for Intubation

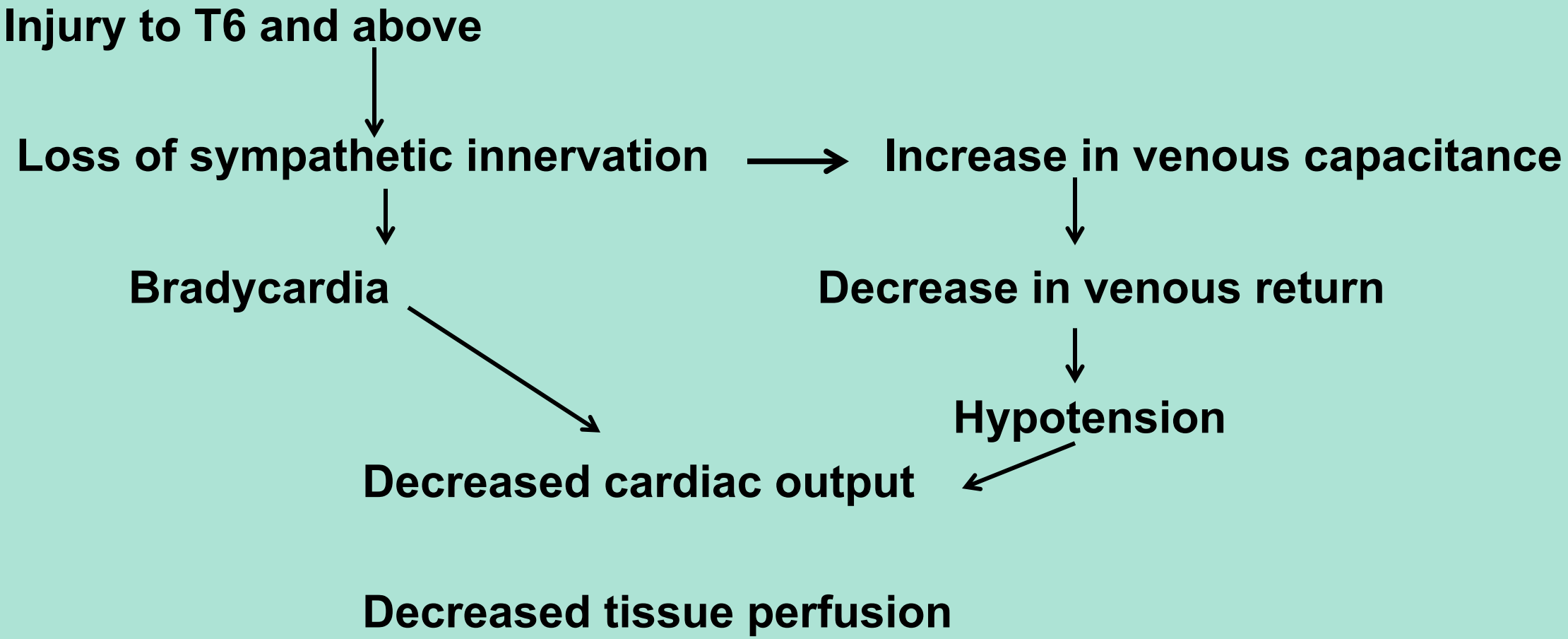
- **Absolute Indications**
  - Complete spinal cord injury above C5 level
  - Respiratory Distress
  - Hypoxemia despite adequate attempts at oxygenation
  - Severe Respiratory Acidosis
- **Relative Indications**
  - Complaint of Shortness of Breath
  - Increase work of breathing
  - Vital Capacity < 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

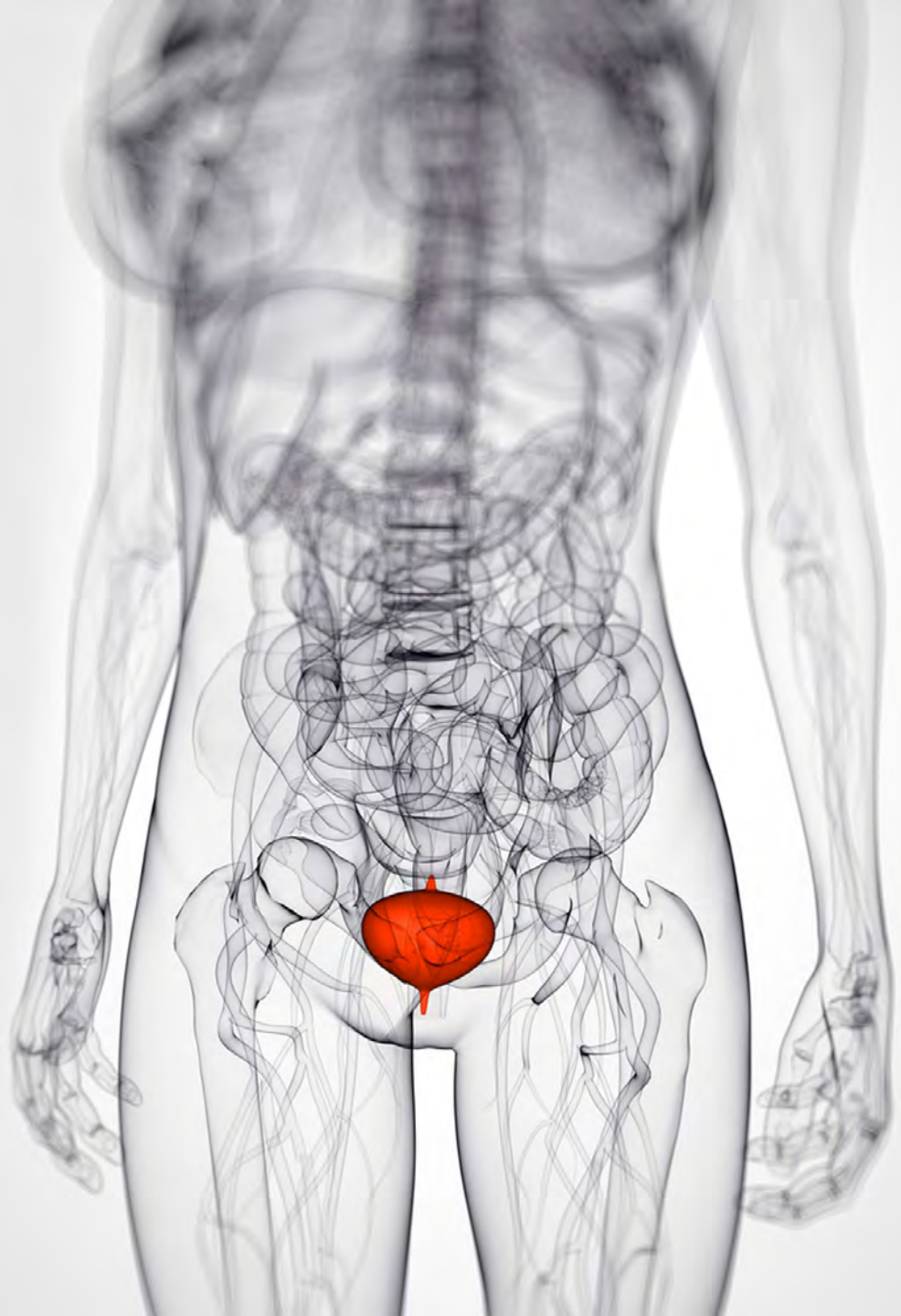


Neurogenic Shock



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^{o}C intravascular cooling
  - Rapid application and close monitoring
  - Anecdotal papers
  - No peer reviewed/class I clinical research
  - Studies in progress

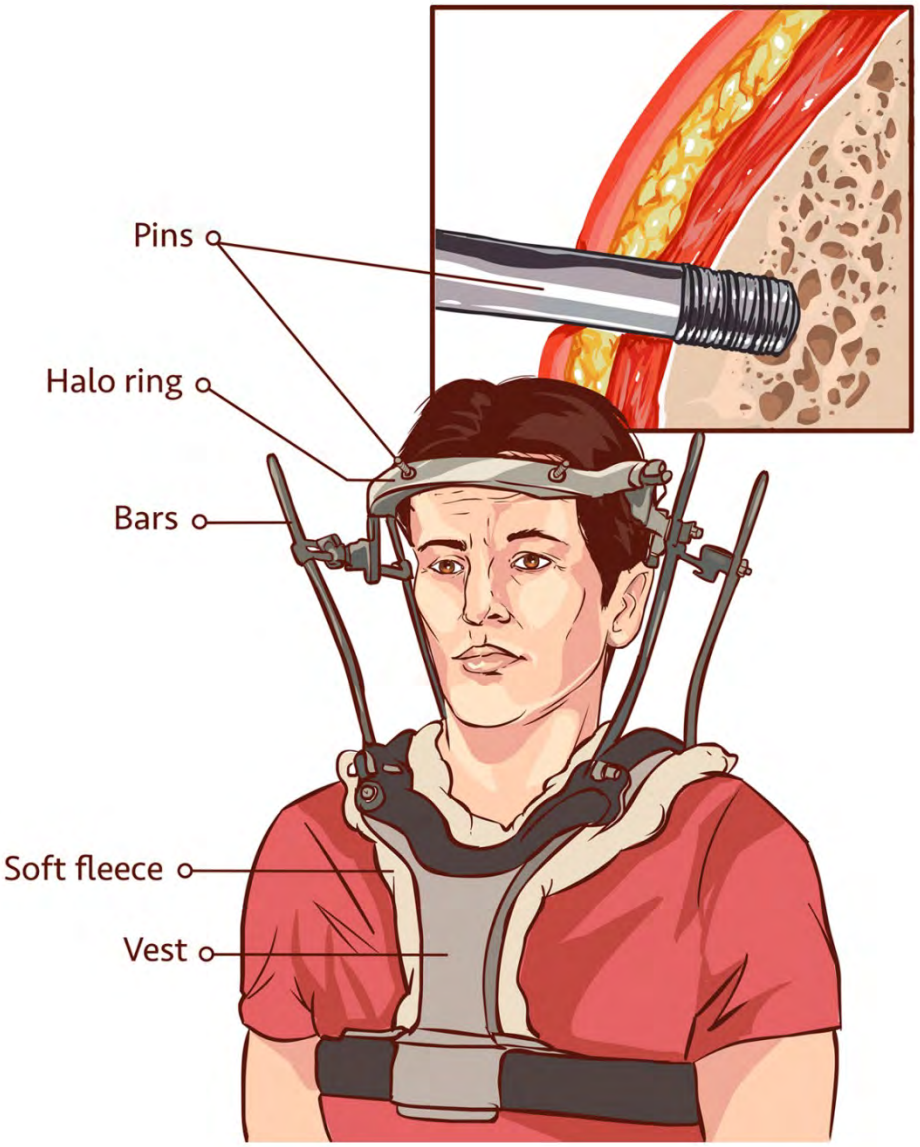
Neuroprotective Agents

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

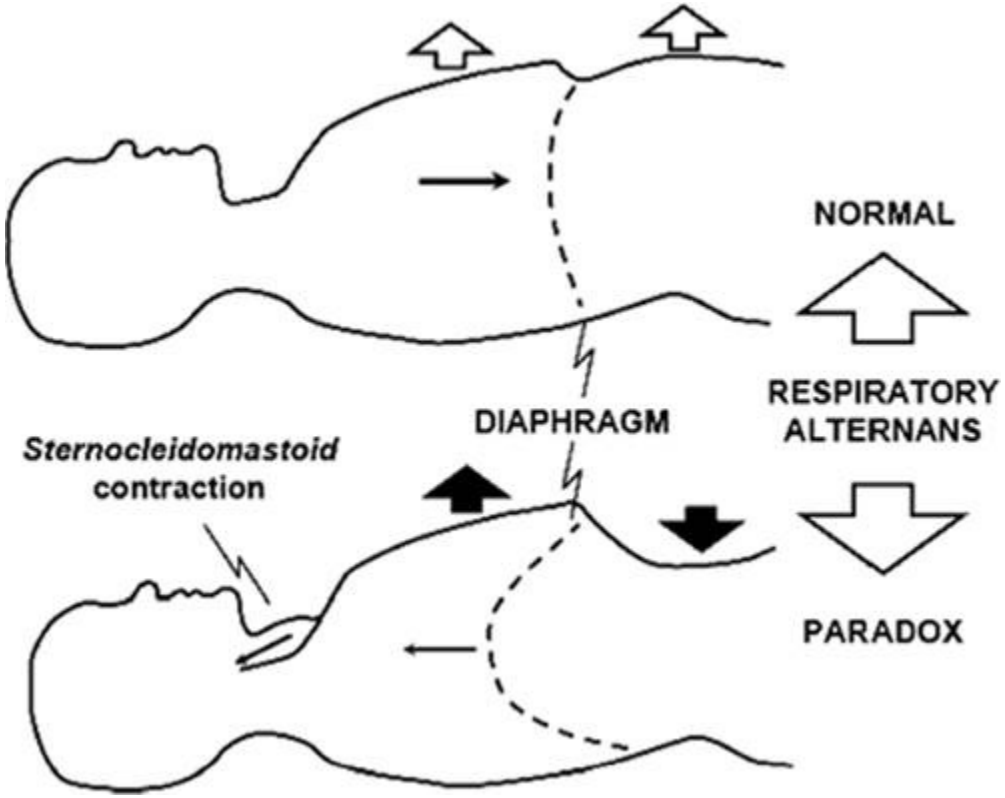
Surgical Management

- 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

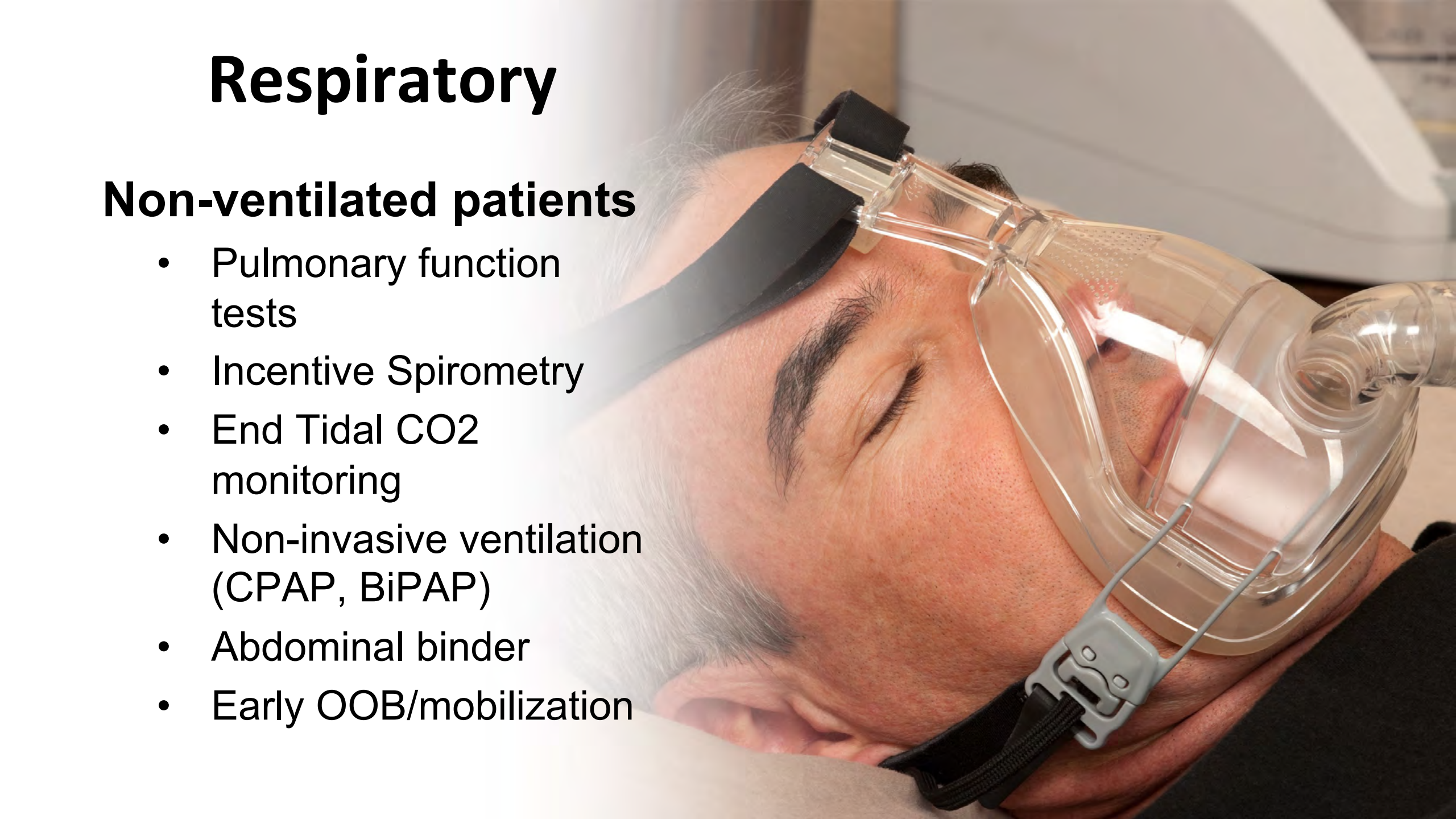


https://medicinespecifics.com/paradoxical-breathing-abdominal-paradox-mechanism/

Respiratory

Non-ventilated patients

- Pulmonary function tests
- Incentive Spirometry
- End Tidal CO2 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

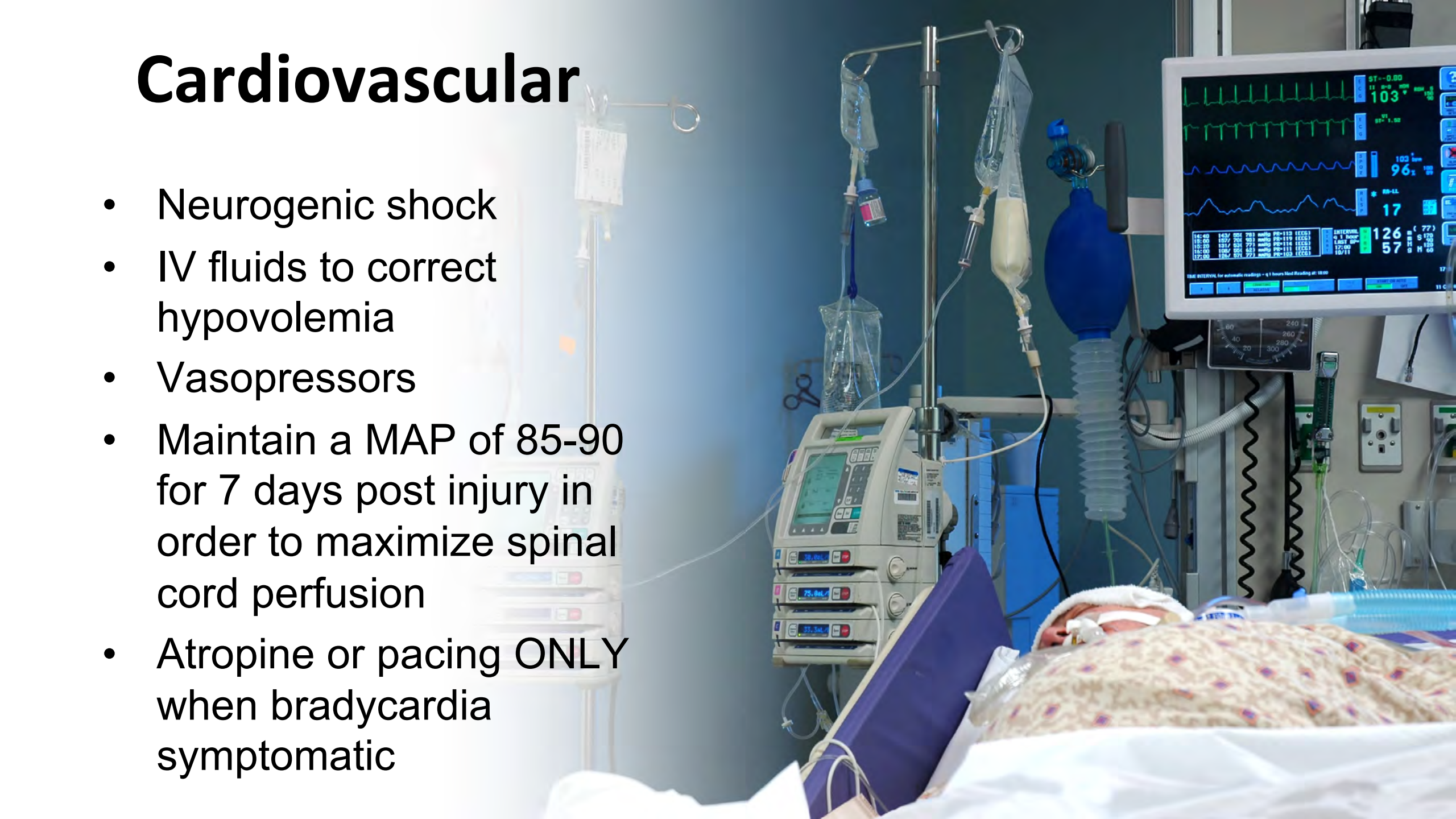
Respiratory

Pulmonary management

- Weaning parameters
- Monitor SpO2 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
  - Nasogatric 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

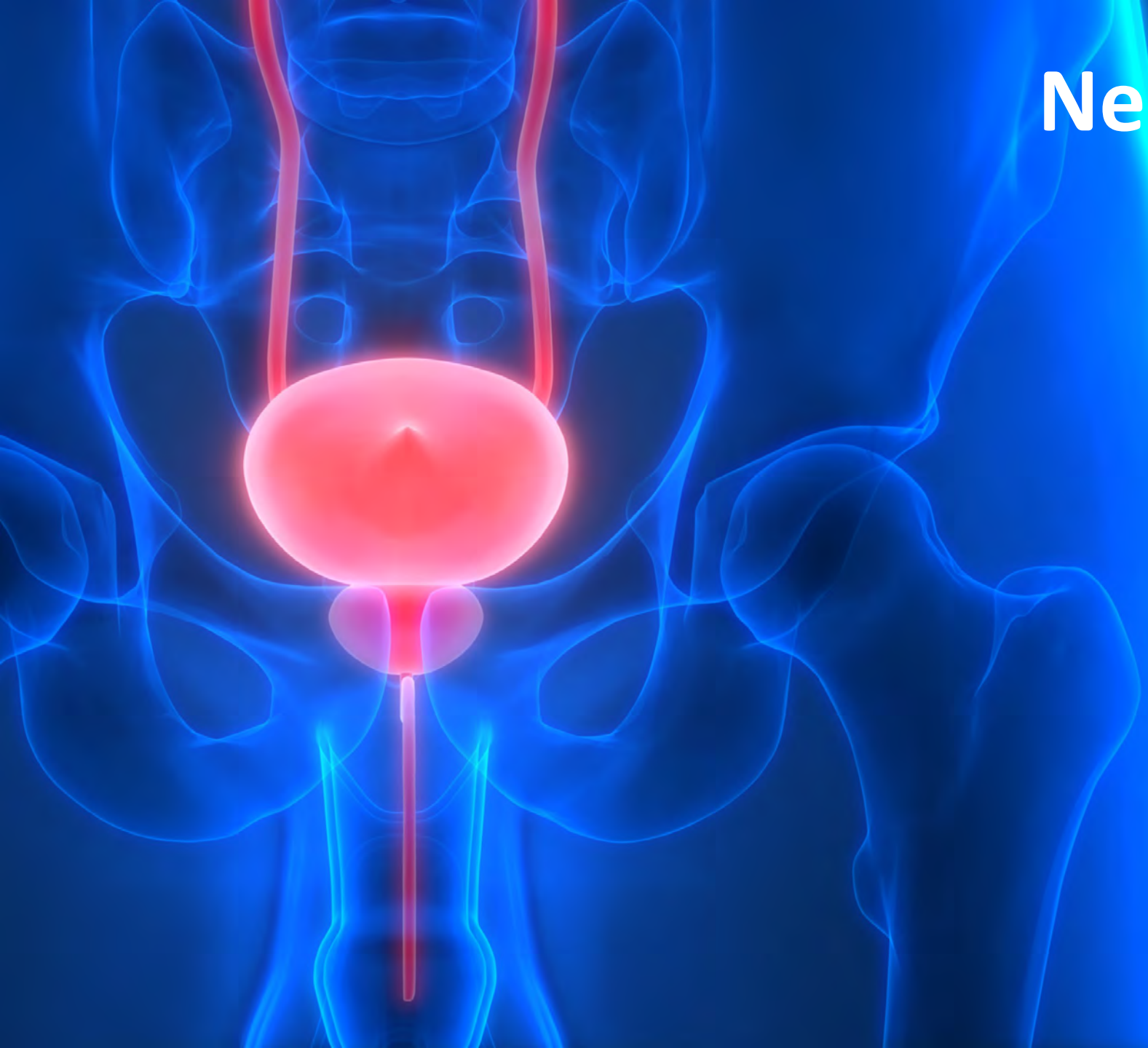
Gastrointestinal

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



Neurogenic Bladder

- Involuntary contraction
- Reflex initiated voiding when bladder full
- Fluid restriction
- Transition to straight catherization, 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

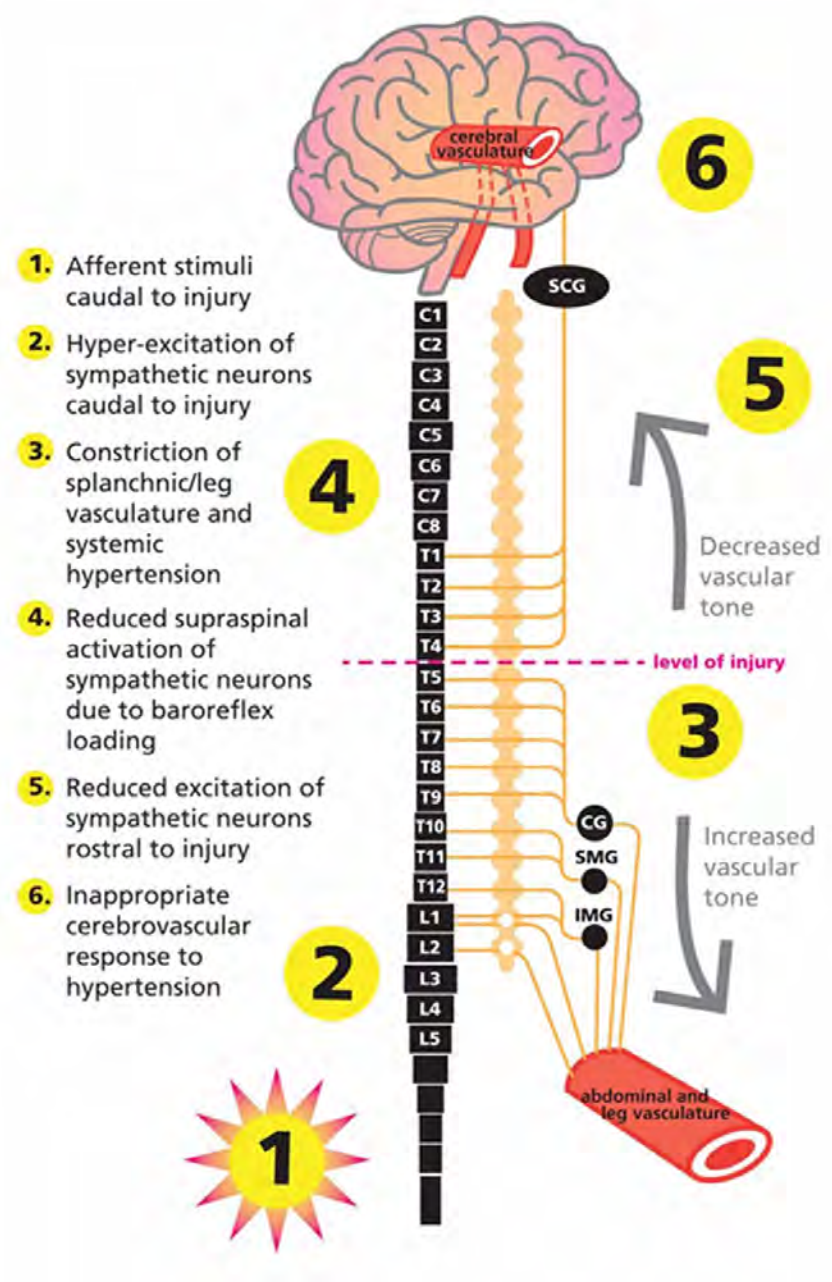
- Imbalance of muscle innervation
- Certain muscle groups become stronger than the opposing muscle
- Can lead to loss of function and functional independence
- PREVENTION – aggressive ROM, mobilization, PT/OT, splinting, positioning, serial casting, anti-spasmodics
- Rehabilitation Services consults

Heterotopic Ossification

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

Bickle, Radiopaedia.org

Autonomic Dysreflexia



Squair, 2016

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

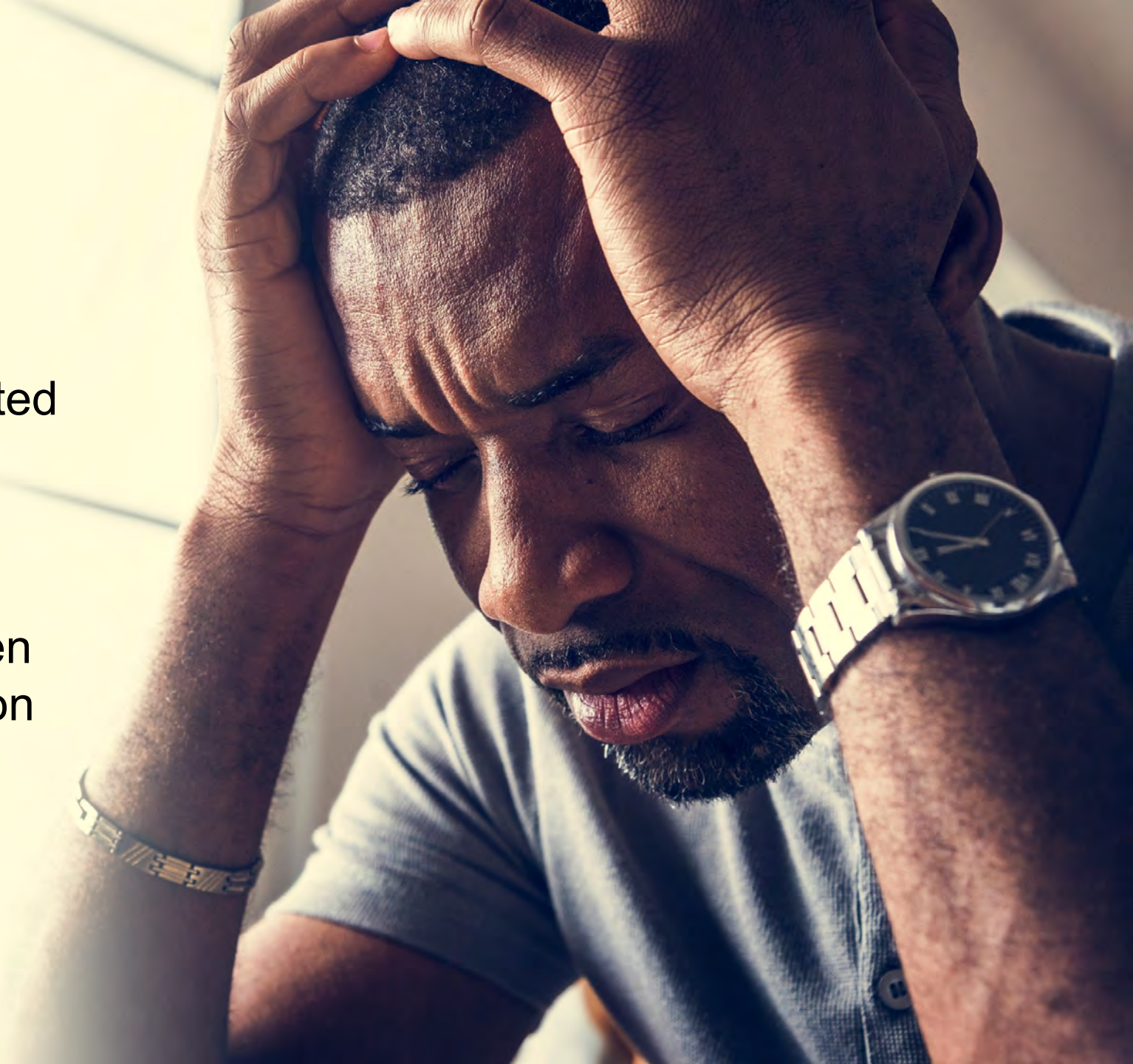
Autonomic Dysreflexia

- 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

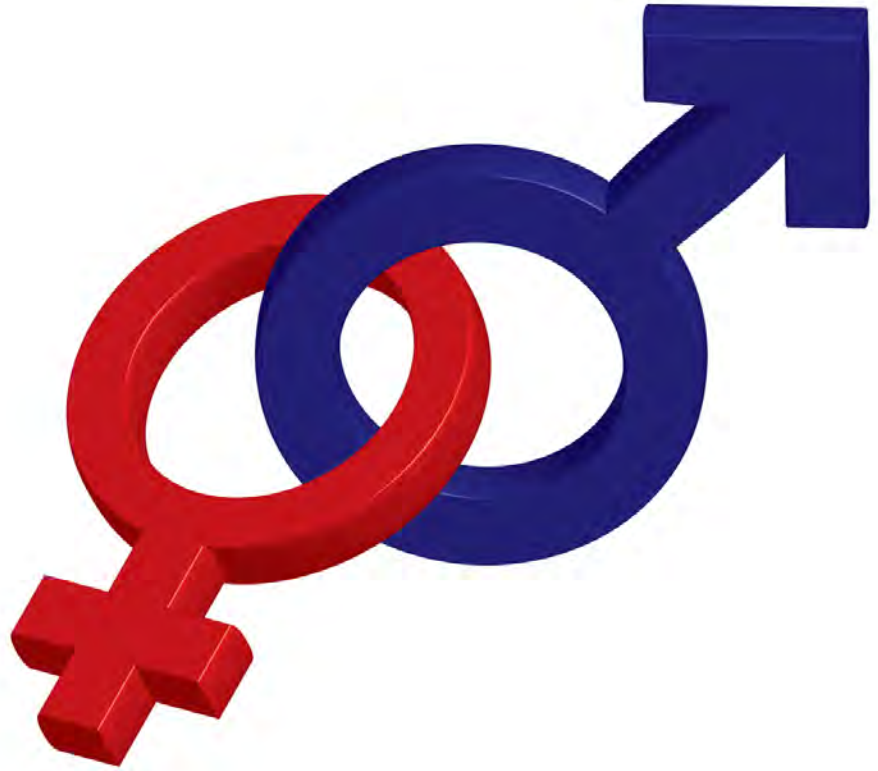
- Nocioceptive – noxious stimuli to normally innervated parts
- Neurogenic – nerve tissue injury in CNS or PNS
- Strong relationship between pain and anxiety/depression
- Counseling, ROM, pharmacologic treatment, TENS



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.

Spinal Column and Spinal Cord Injuries

1. Spinal cord injury is significant in the United States because:
    a. Despite low incidence, it carries a high economic burden
    b. Primarily is the result of a violent event
    c. Reduced life expectancy is common
    d. It primarily occurs in older persons

2. The Autonomic Nervous System (ANS) is important in acute spinal cord injury because:
    a. The parasympathetic branch is disrupted producing neurogenic shock
    b. The sympathetic branch is disrupted producing neurogenic shock
    c. The hypothalamus is injured producing neurogenic shock
    d. The ANS is not important because it is part of the peripheral nervous system

3. The five major mechanisms of injury are:
    a. Flexion, extension, axial loading, distraction, and laceration
    b. Concussion, flexion, extension, rotation, and penetration
    c. Flexion, extension, axial loading, rotation and penetration
    d. Flexion, extension, concussion, distraction, and penetration

4. Central cord syndrome is:
    a. A result of forces producing an injury in the periphery of the spinal cord
    b. Most commonly occurs in older persons with degenerative changes of the cervical spine
    c. Characterized by a disproportionate loss of lower extremity versus upper extremity function
    d. Most often associated with penetrating injuries

5. The sensorimotor exam is performed:
    e. To evaluate function of the lateral corticospinal, the lateral reticulospinal, and the lateral spinothalamic tracts
    a. To assess sensory and motor function and strength bilaterally
    b. Upon admission only to help localize level of injury
    c. Routinely to assist patient's in recognizing the extent of their injury

6. The cardiovascular consequences of neurogenic shock include:
    a. Hypertension, tachycardia, and hyperthermia
    b. Hypotension, bradycardia, and hypothermia
    c. Hypotension, tachycardia, and hyperthermia
    d. Hypertension, bradycardia, and hyperthermia

7. The signs and symptoms of autonomic dysreflexia include:

a. Hypotension, tachycardia, sweating, and pallor
b. Hypertension, bradycardia, pallor, and flushing
c. Hypertension, tachycardia, flushing, and hyperventilation
d. Hypotension, tachycardia, pallor, and goosebumps

8. Frequent respiratory assessment is important in acute spinal cord injury because:

a. Loss of defensive respiratory muscles places them at high risk for respiratory failure
b. Arterial blood gas results can be inaccurate in these patients
c. They frequently develop phrenic innervation, which can be worsened by the use of steroids
d. It is the third leading cause of death for quadriplegic patients

9. Which of the following statements is true regarding acute spinal cord injury and deep venous thrombosis?

a. Infrequently at risk for DVT
b. Patients are at greatest risk the first two weeks post-injury
c. Prophylaxis need only be managed with anti-coagulation
d. All patients must have a prophylactic vena cava filter placed

10. Gastrointestinal management of a patient with an acute spinal cord injury should include:

a. Gastric decompression, steroids, and gastric prophylaxis
b. Gastric decompression, steroids, and bowel stimulants
c. Gastric decompression, delayed nutrition due to risk of ileus, and bowel stimulants
d. Gastric decompression, gastric prophylaxis, early enteral feedings, and bowel stimulants

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