Spinal cord injury

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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 effects of spinal cord injury on the rest of the body

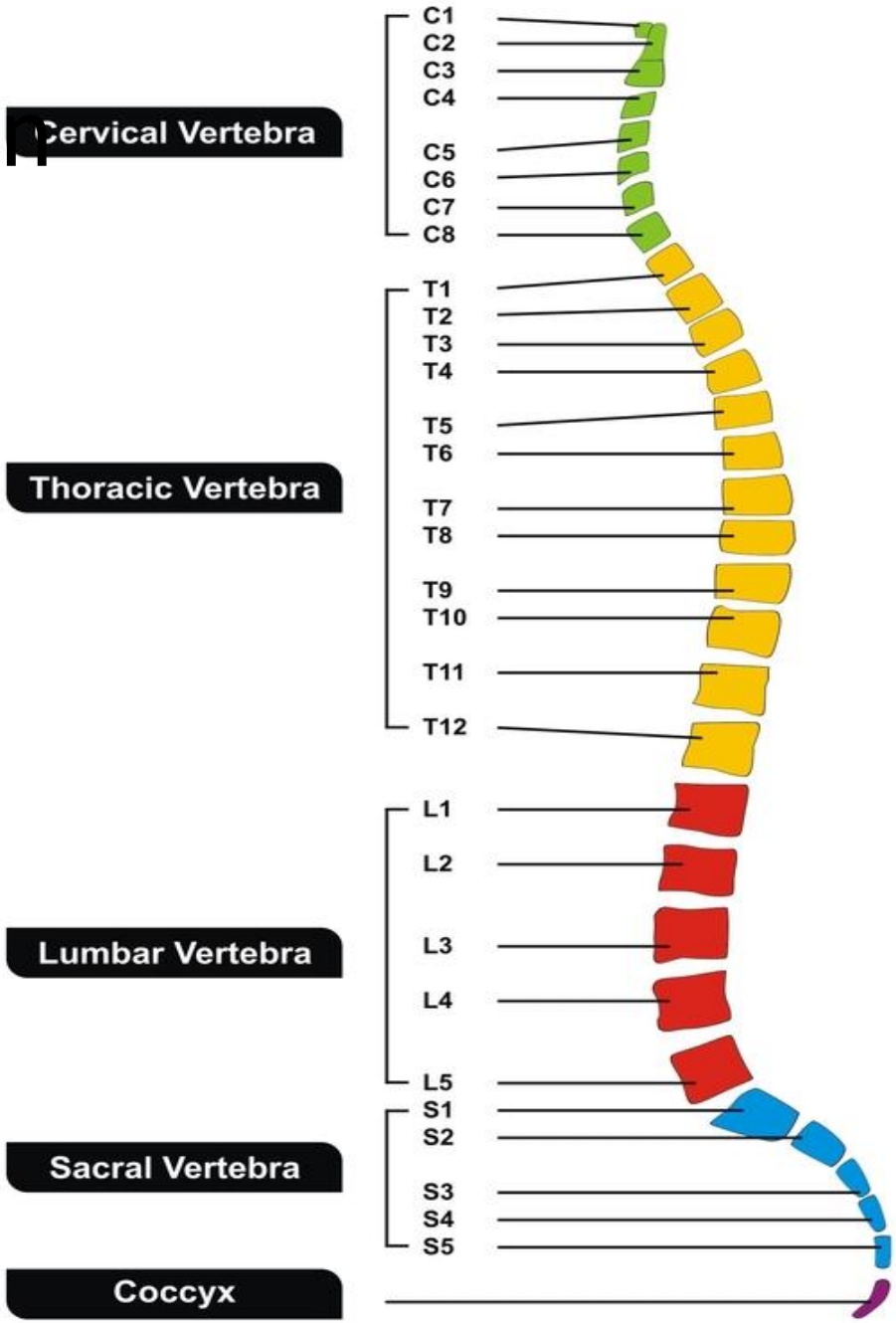
Epidemiology

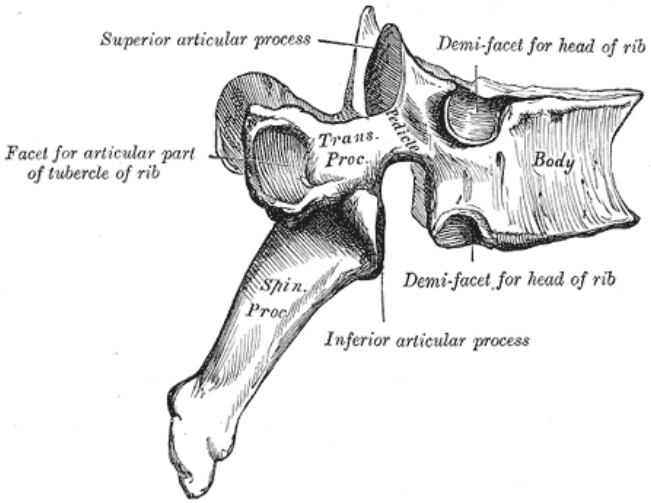
- Approx 12,000 new cases per year
- Average age 40.7 years
- 80.7% male
- Increased incidence among African Americans (27%) and Asians (2%)
- Most common causes - MVC (41%), Falls, Violence

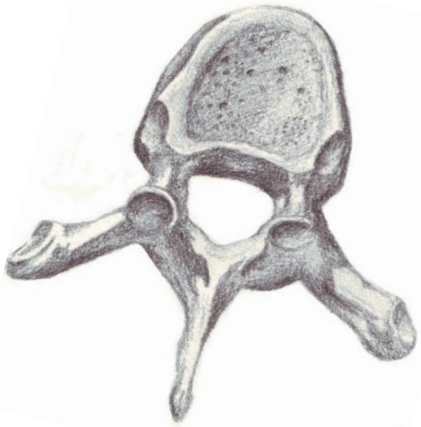
Anatomy and Physiology

- Vertebrae
- Discs
- Ligaments
- Spinal cord
- Vessels

Vertebral Column







Thoracic vertebra

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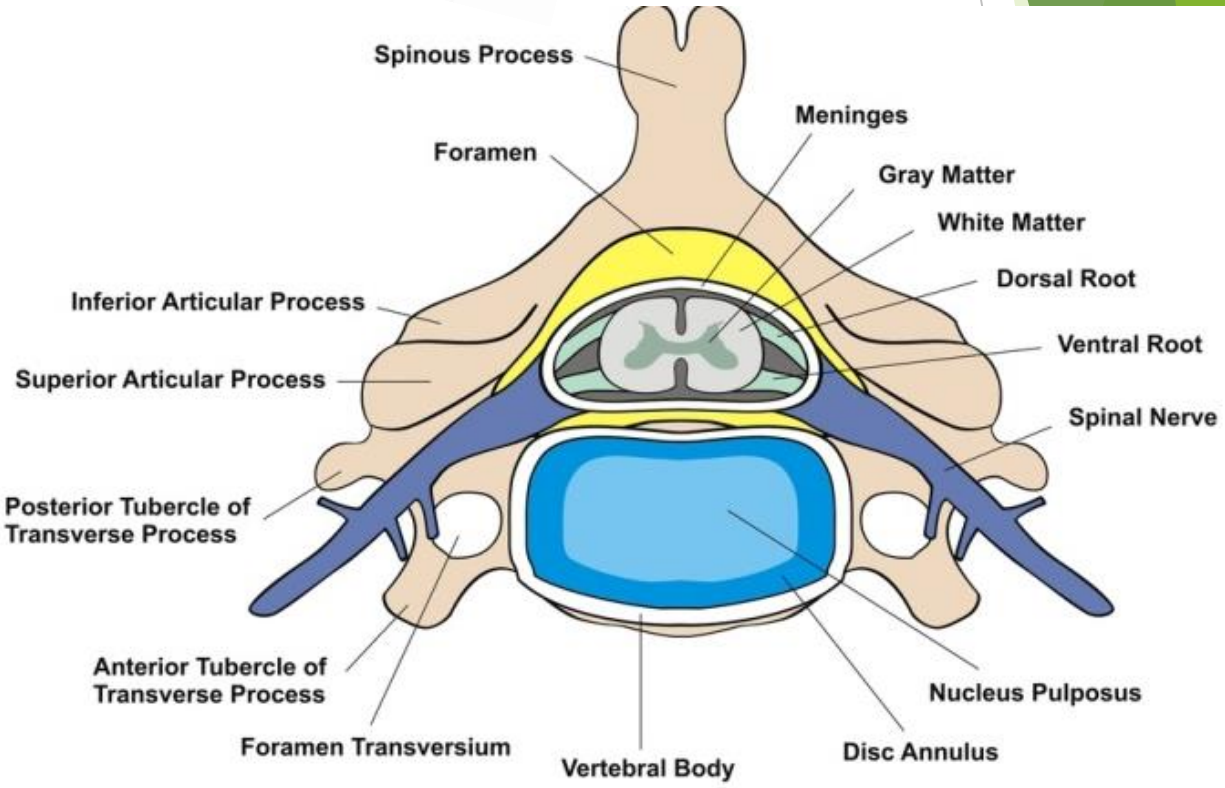
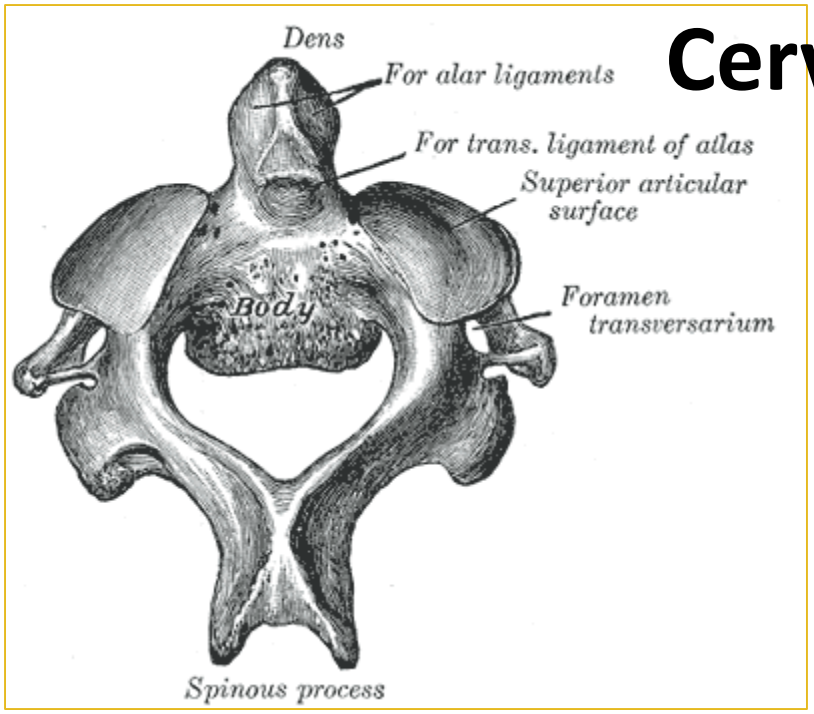
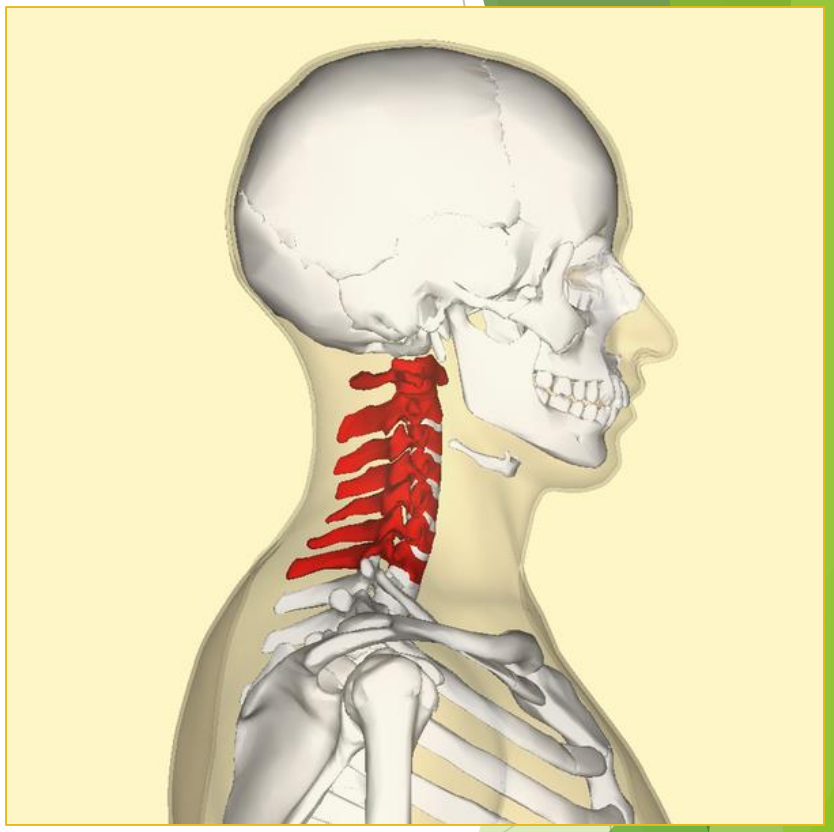
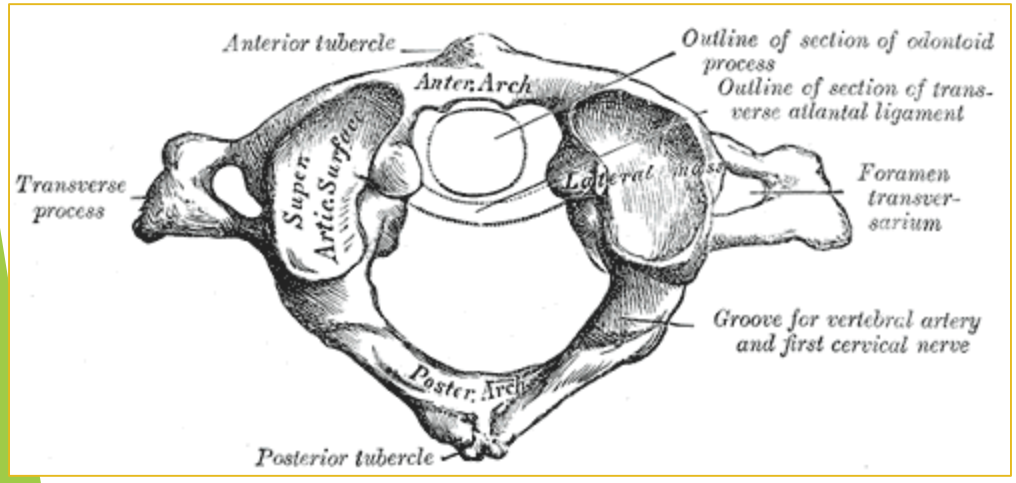
Vertebra



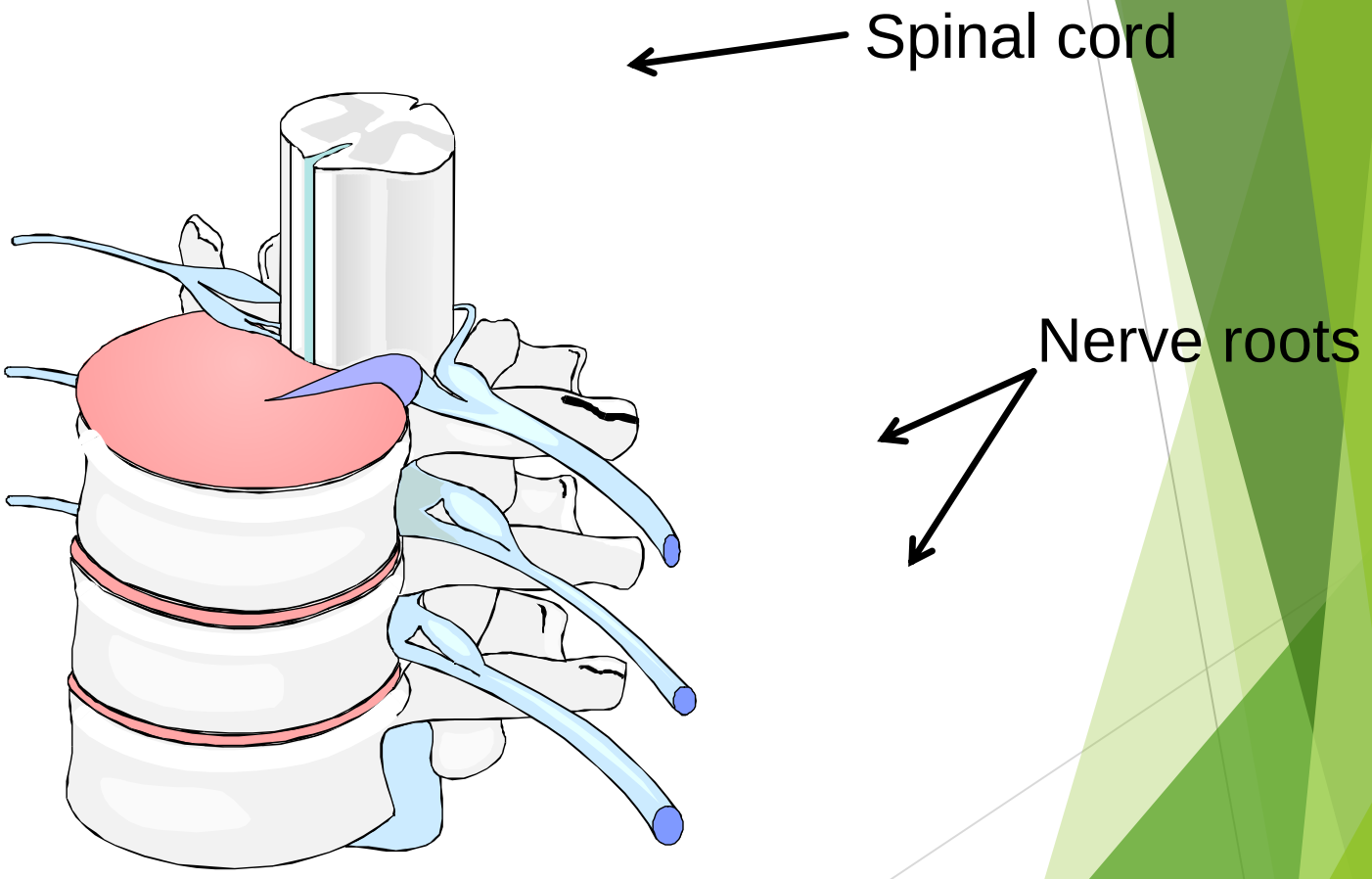
Cervical Vertebrae





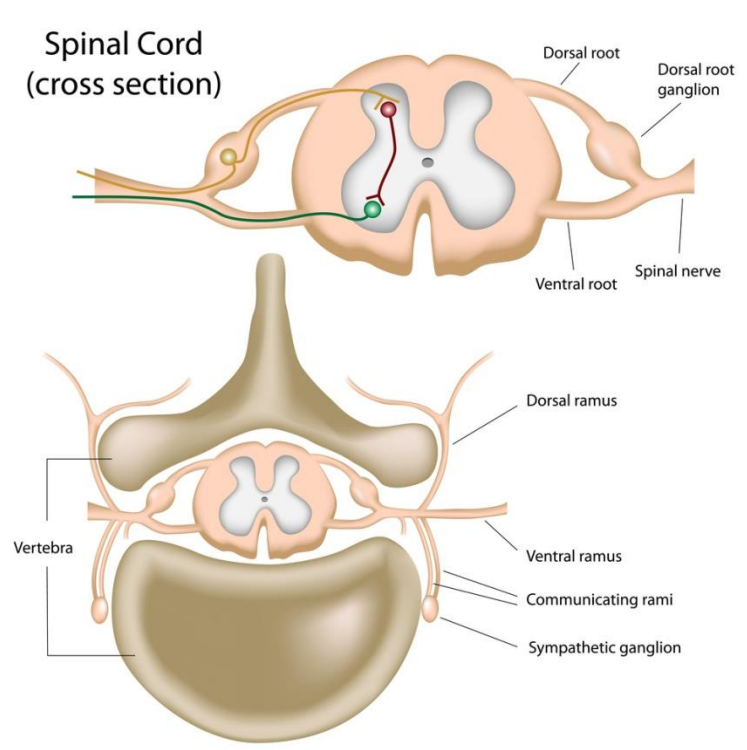


Spinal Cord



Anatomy and Physiology

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

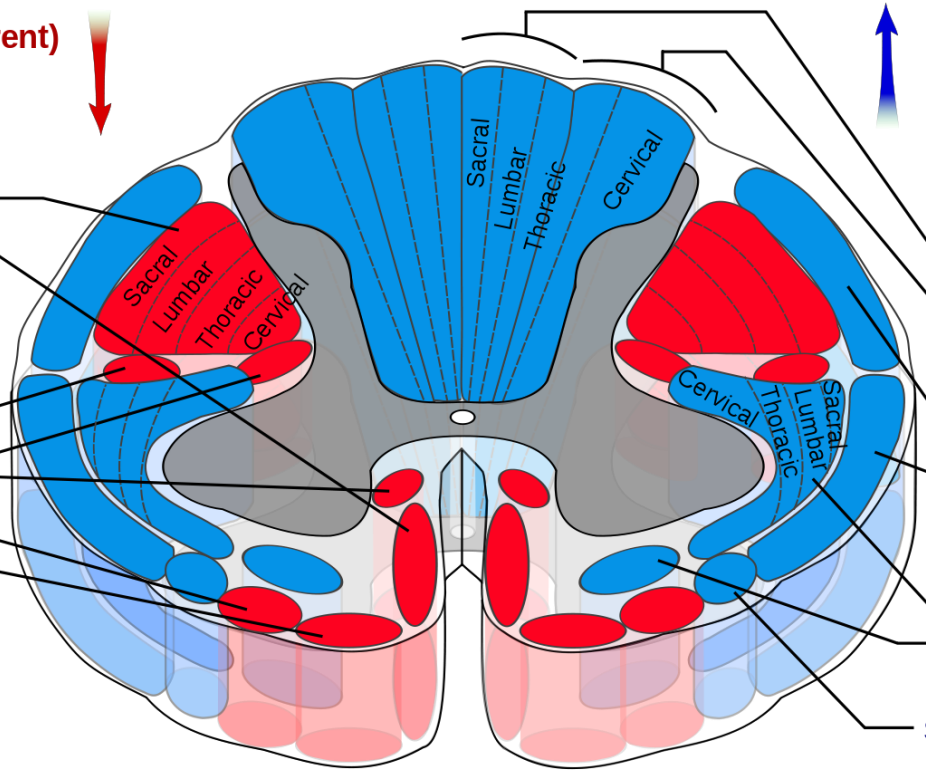


Spinal Cord

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

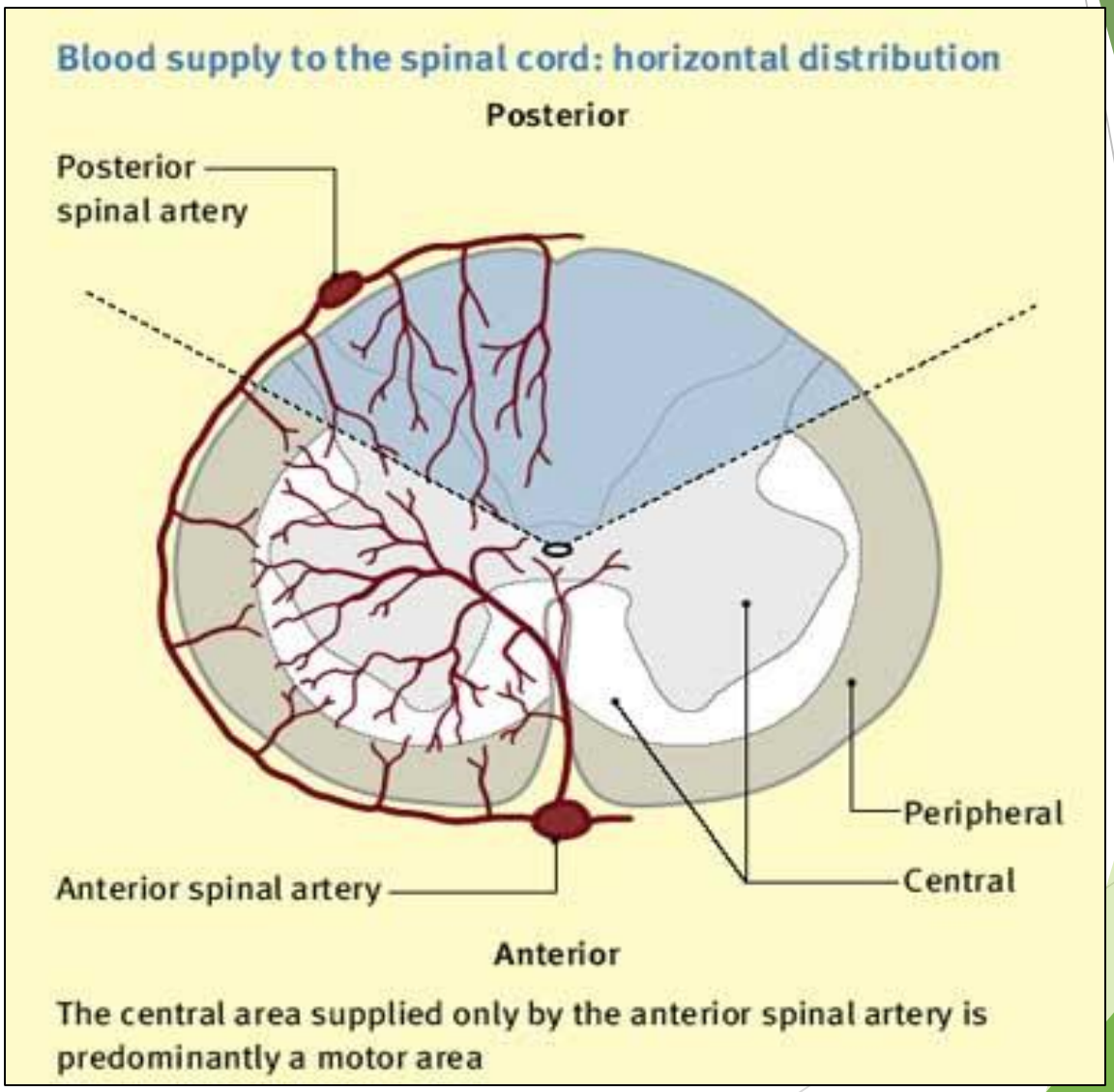
Anterolateral System
- Lateral spinothalamic tract
- Anterior spinothalamic tract

Spino-olivary fibers

Anatomy and Physiology

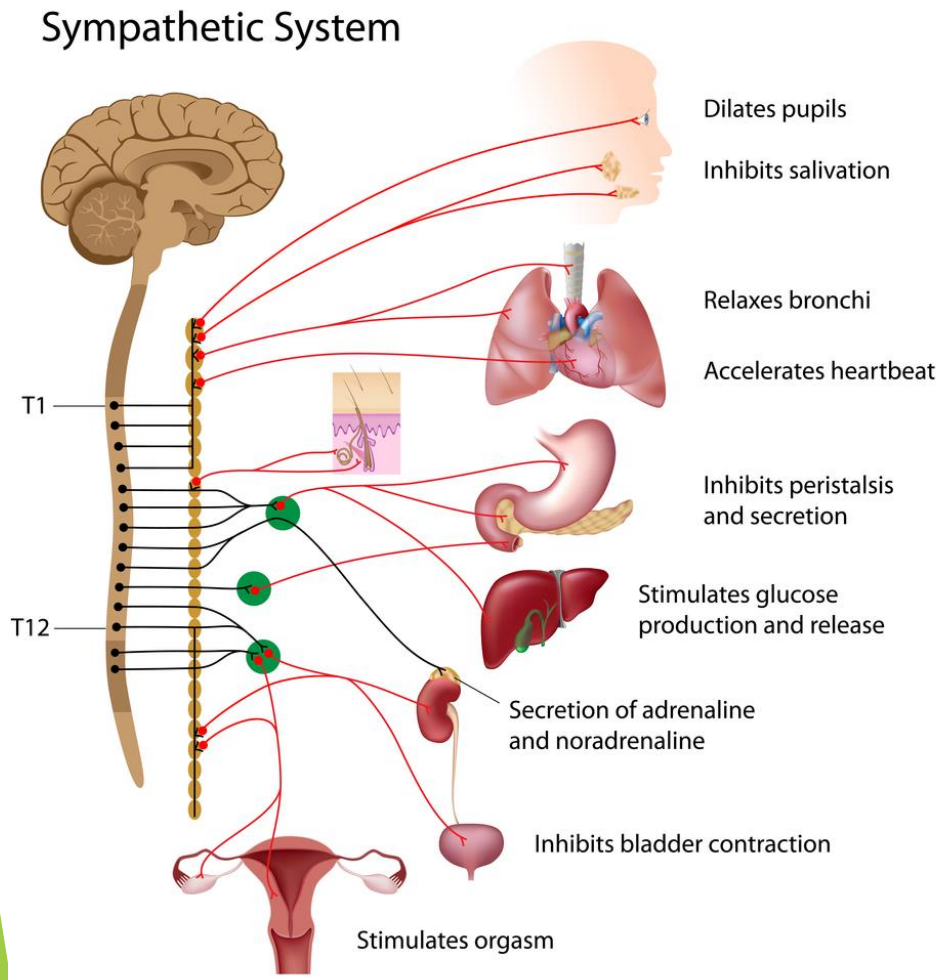
- Upper motor neuron (UMN)
  - Modulated by cerebrum, cerebellum, basal ganglia, reticular neurons
  - Injury = paralysis, hypertonicity, hyperreflexia
- Lower motor neuron (LMN)
  - Originated in CNS
  - Injury = flaccidity, hyporeflexia, fasciculations

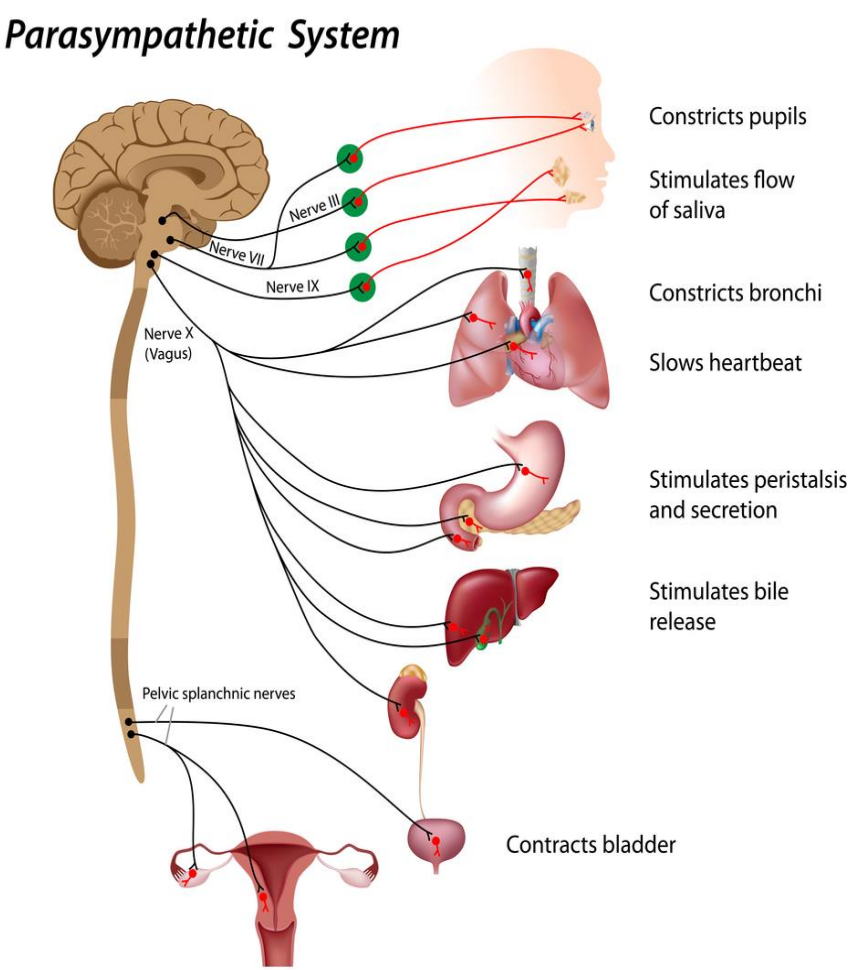
Anatomy and Physiology



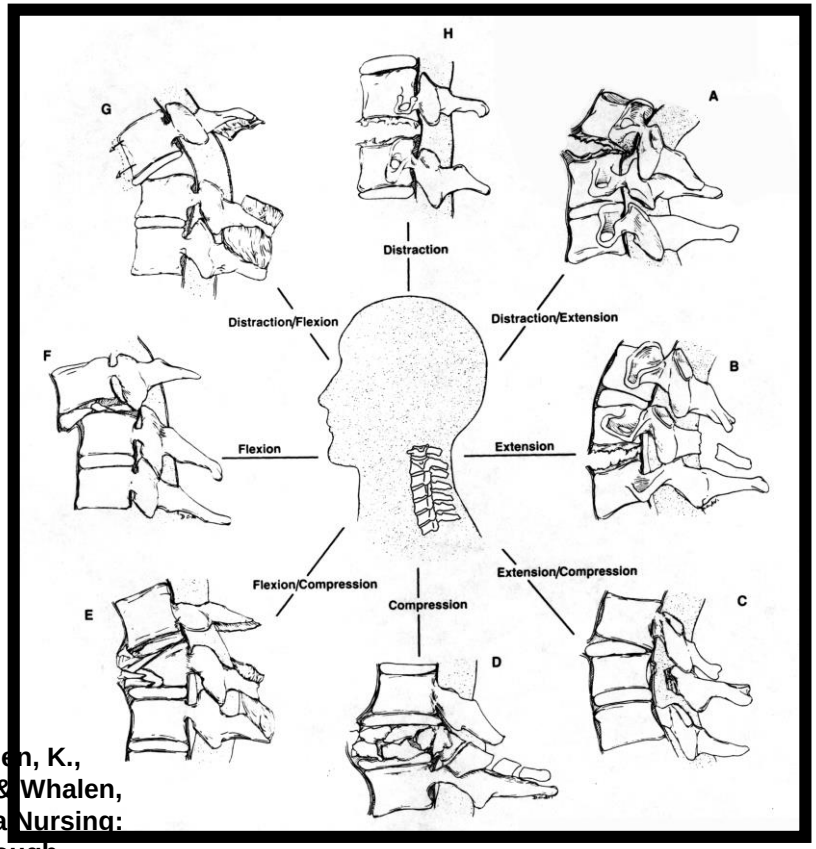
http://pt851.wikidot.com/spinal-cord-injury-cell-biology

Anatomy and Physiology





Mechanisms of Injury



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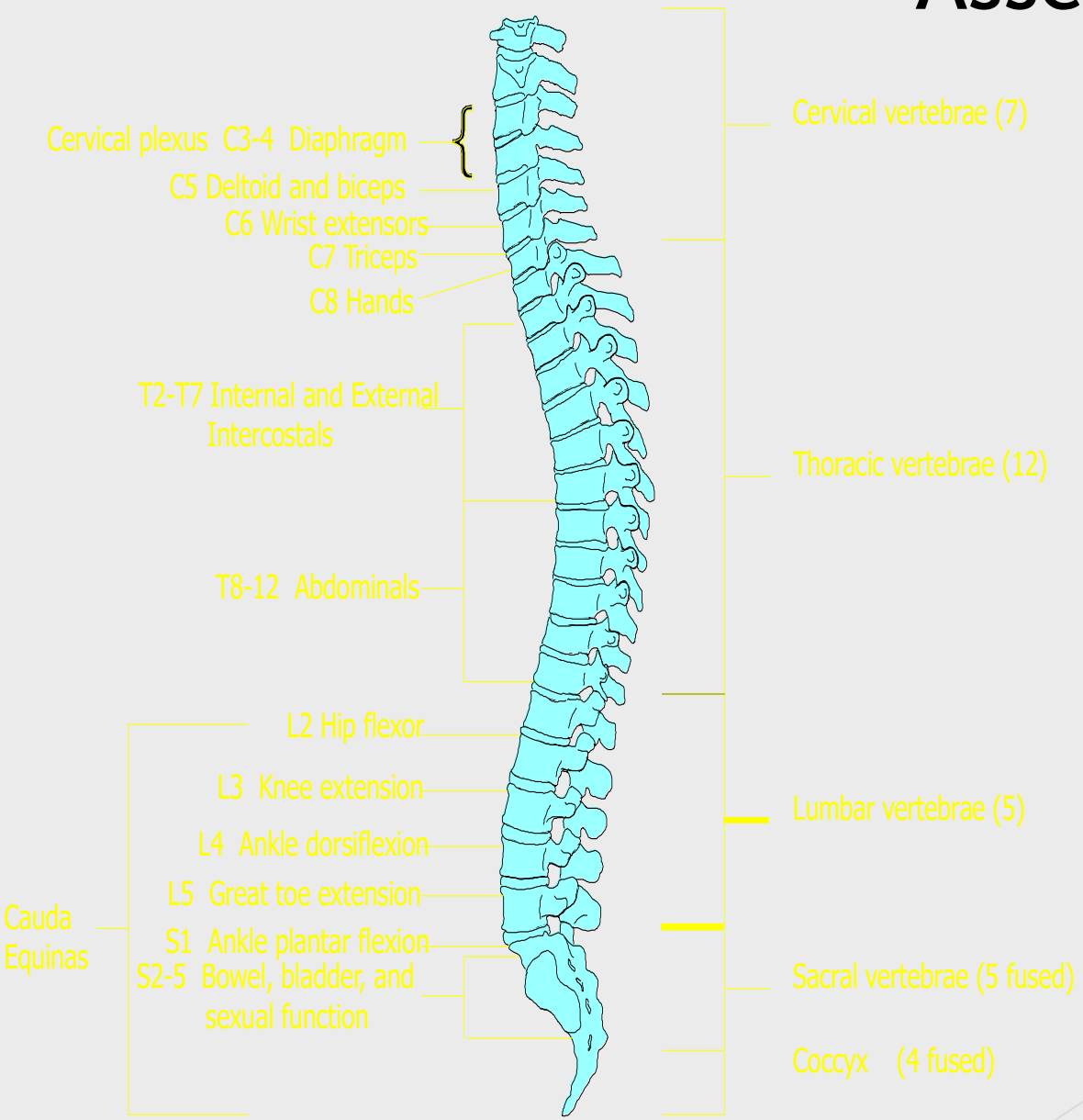
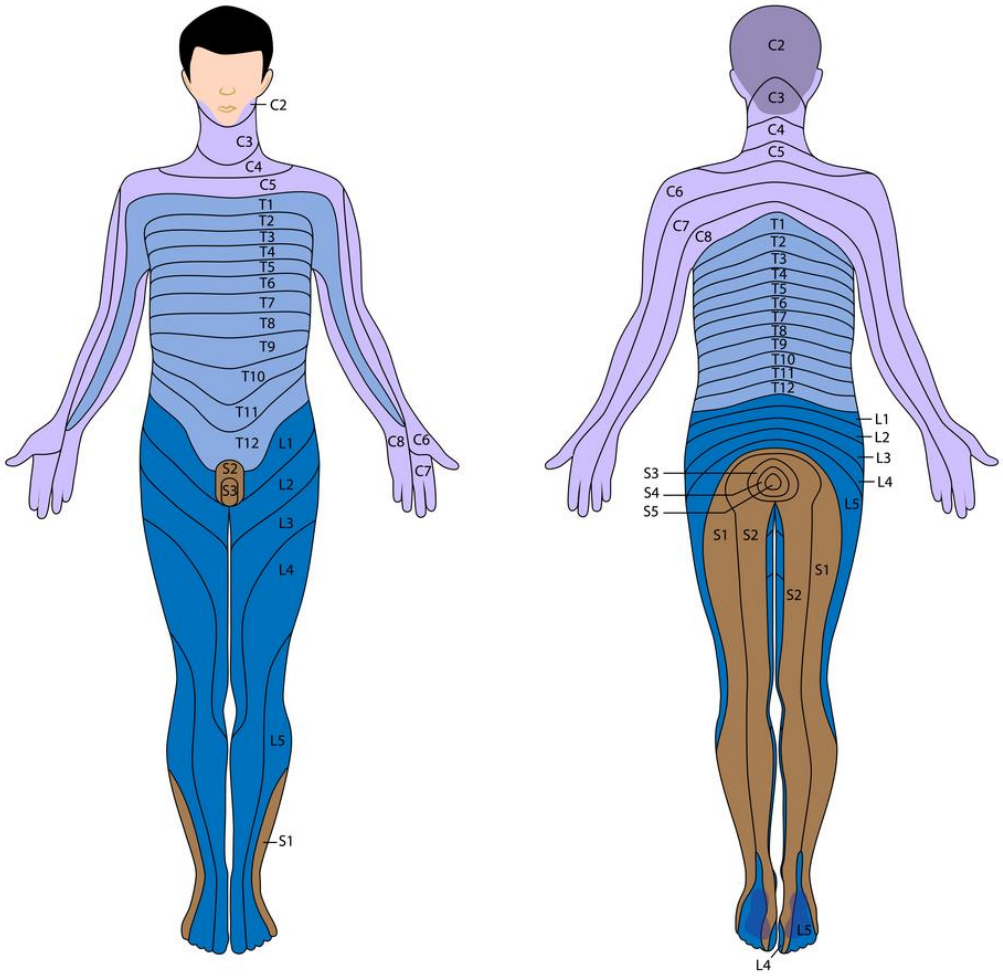
Initial Management

- Pre-hospital
- Resuscitation

Assessment


Cervical plexus C3-4 Diaphragm
C5 Deltoid and biceps
C6 Wrist extensors
C7 Triceps
C8 Hands
T2-T7 Internal and External Intercostals
T8-12 Abdominals
L2 Hip flexor
L3 Knee extension
L4 Ankle dorsiflexion
L5 Great toe extension
S1 Ankle plantar flexion
S2-5 Bowel, bladder, and sexual function
Cauda Equinas
Cervical vertebrae (7)
Thoracic vertebrae (12)
Lumbar vertebrae (5)
Sacral vertebrae (5 fused)
Coccyx (4 fused)

Dermatomes


C2
C3
C4
C5
T1
T2
T3
T4
T5
T6
T7
T8
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T10
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T12
L1
L2
L3
L4
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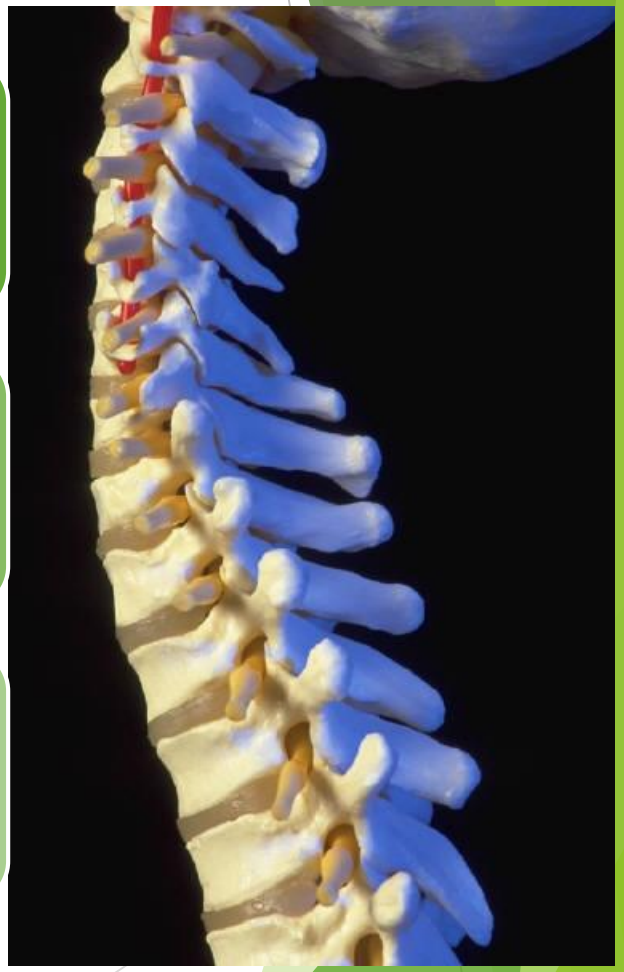
T12
L1
L2
L3
L4
L5
S1
S2
S3
S4
S5
S1
S2
L5
L4

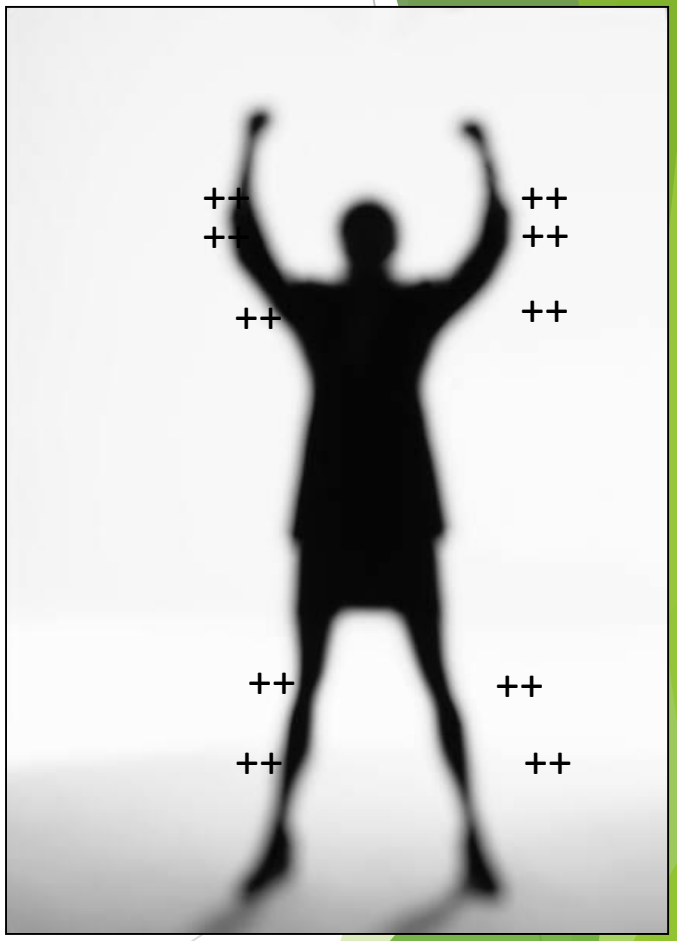
Sensorimotor Assessment

- Lateral corticospinal tract
- Lateral spinothalamic tract
- Dorsal column

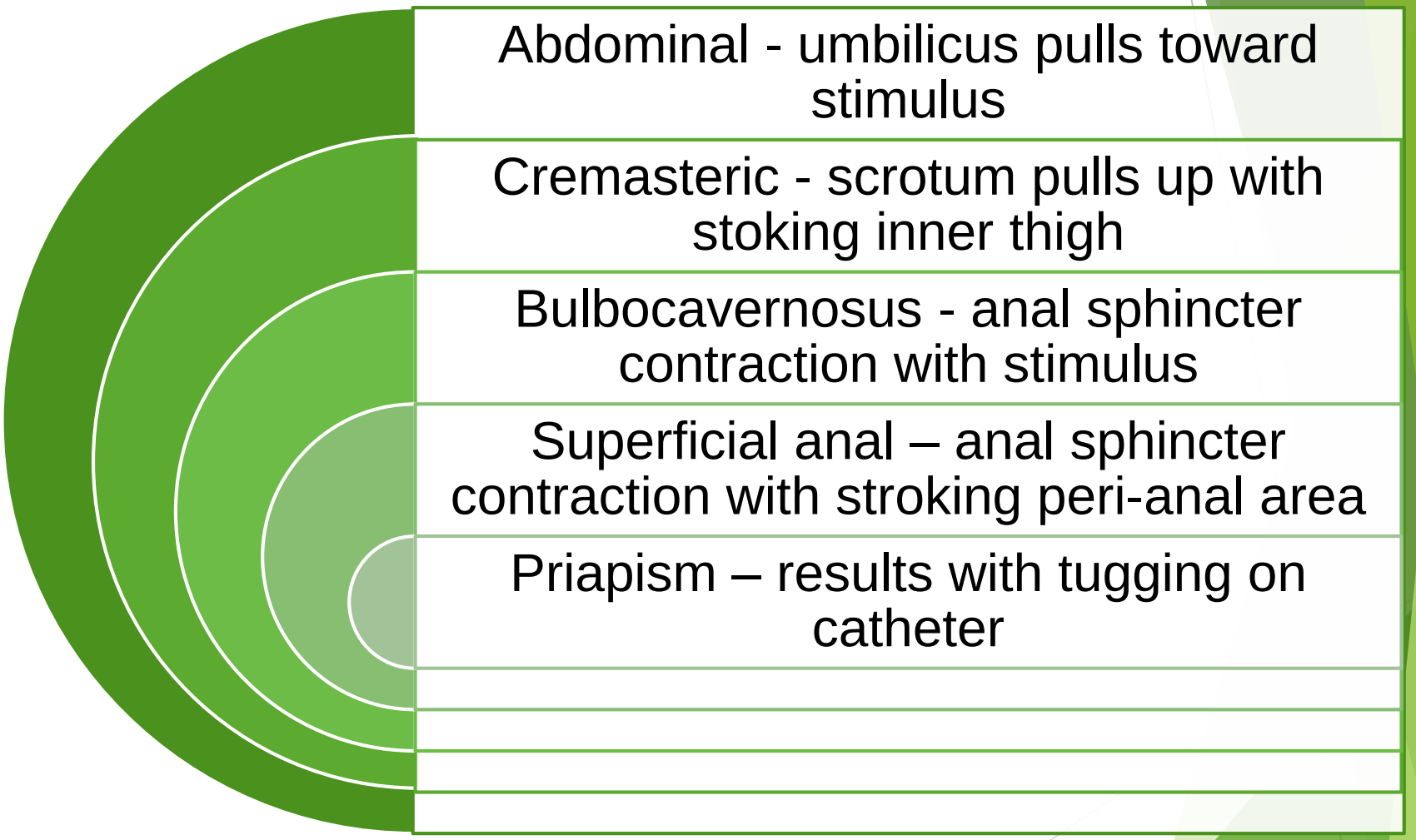


Reflex Assessment

- 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
  - Any incidence of hypotension or hypoxia can result in further injury 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

Cord Syndromes

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

Cord Syndromes

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

Cord Syndromes

- Brown-Sequard
  - Hemisection of the cord usually from penetrating injury
  - Loss motor on side of injury
  - Loss of sensation on the opposite side

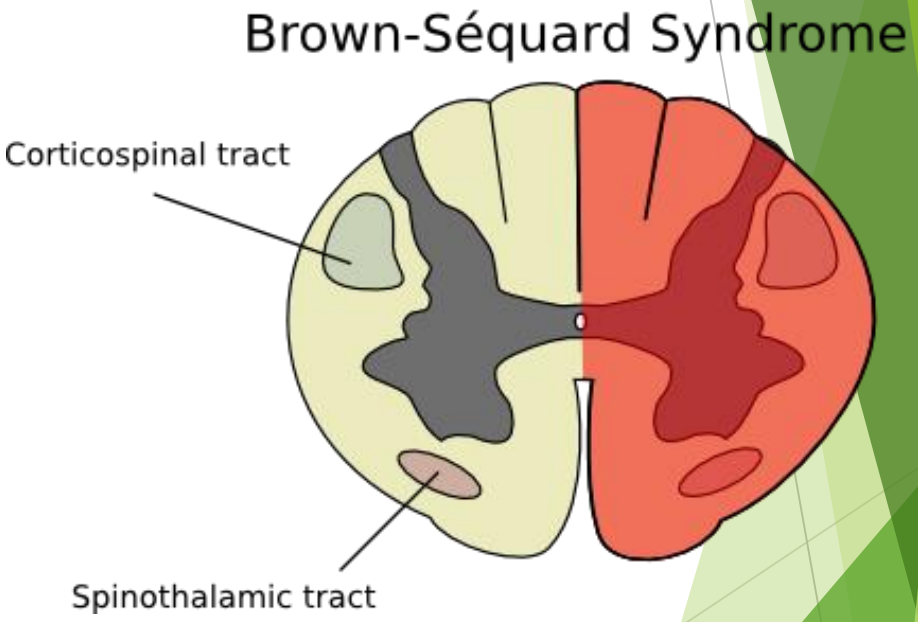


Image found on Wikimedia.org

Cord Syndromes

- **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**
  - Lateral, A/P, odontoid; C-T-L spines
  - May be used for rapid identification of gross deformity
- **CT Scan**
  - Comprehensive, cervical through sacral
  - Demonstrates degree of compression and cord canal impingement
- **MRI Scan**
  - Demonstrates ligamentous, spinal cord injury

Diagnostics

- Clearing the Cervical Spine
  - Awake, alert, and oriented
  - NO distracting injuries
  - NO drugs or alcohol that alter experience
  - NO pain or tenderness
- Clearing spine with films, CT, MRI
  - Complaints of neck pain
  - Neurologic deficit
  - Altered level of consciousness, ventilator

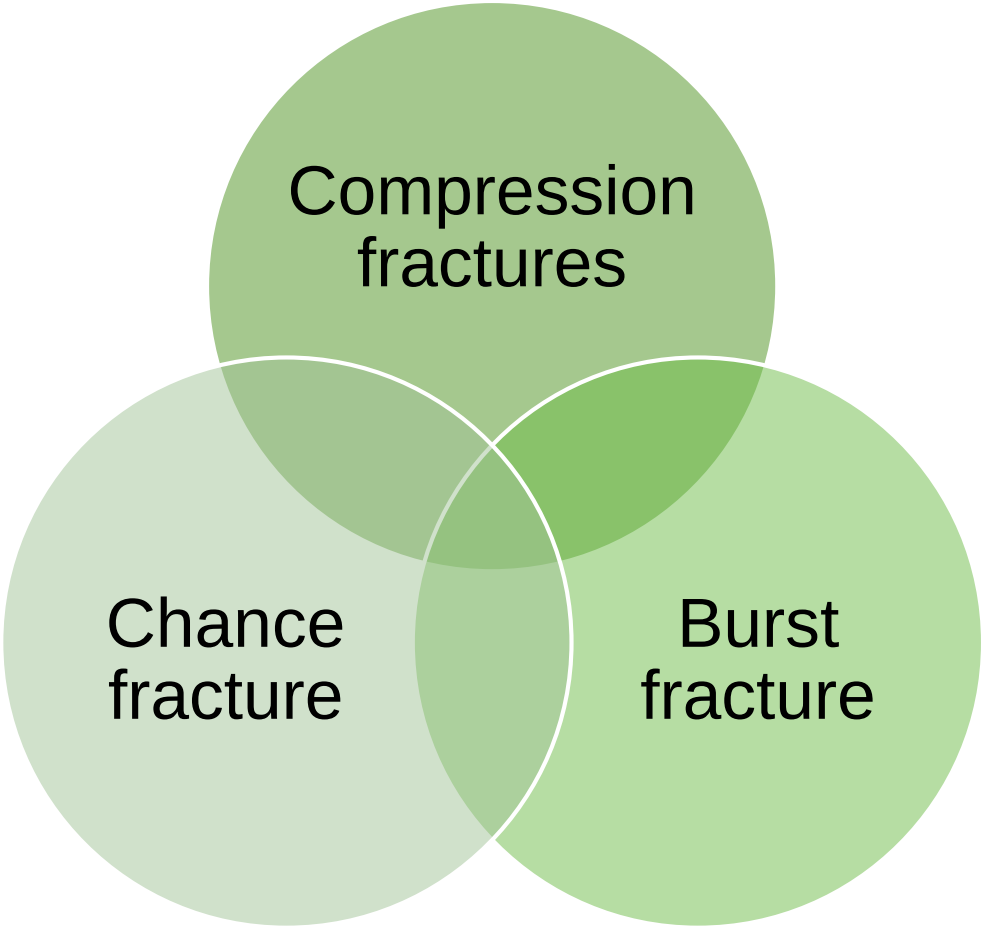
Fractures-Dislocations

- **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



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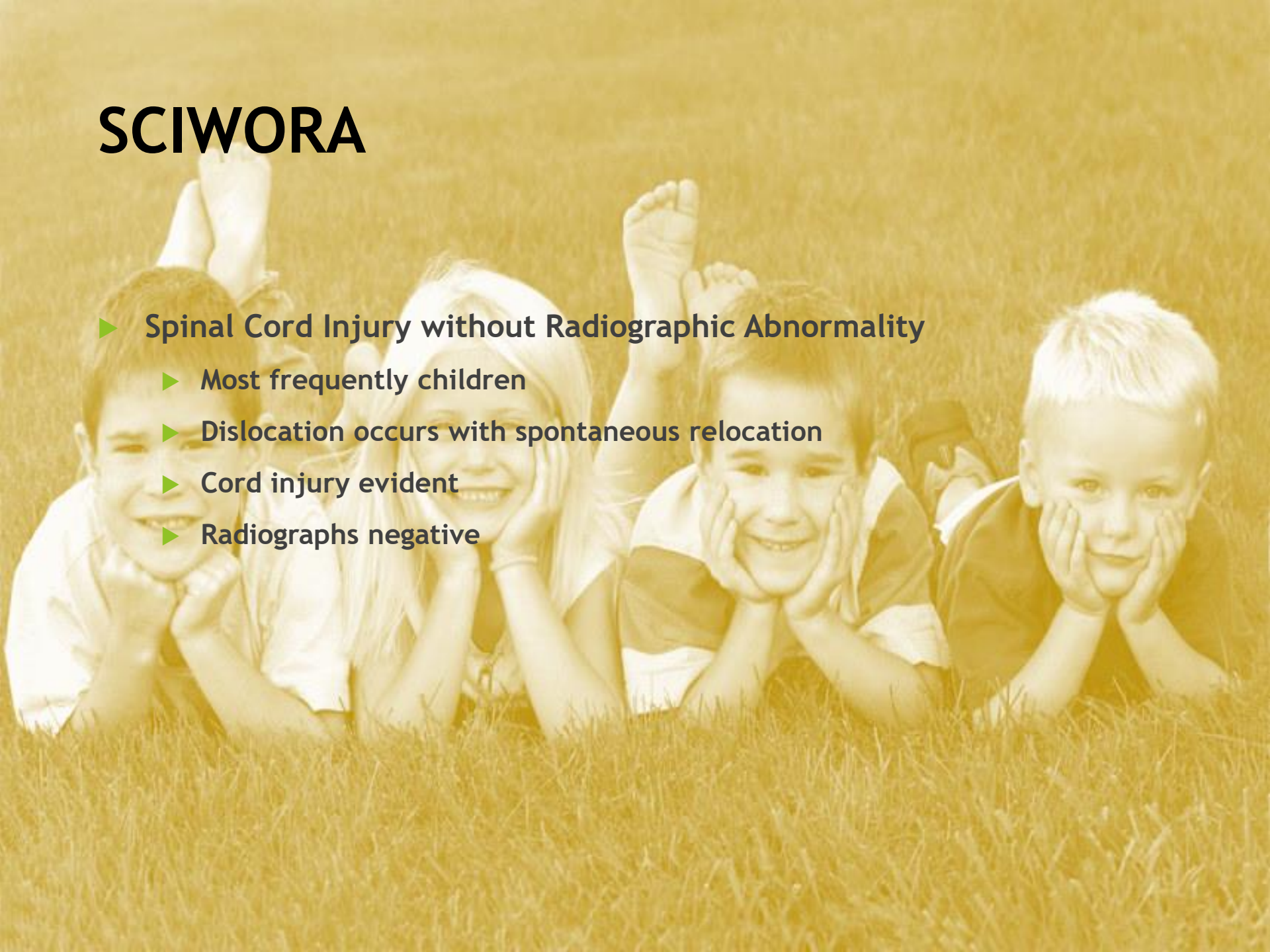


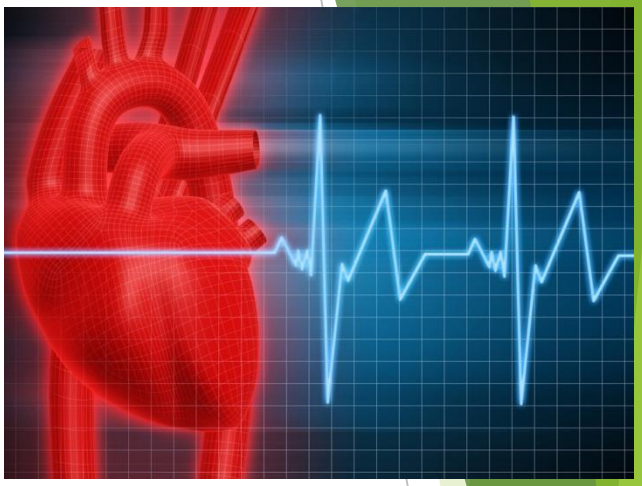
- Spinal Cord Injury without Radiographic Abnormality
  - Most frequently children
  - Dislocation occurs with spontaneous relocation
  - Cord injury evident
  - Radiographs negative

Management

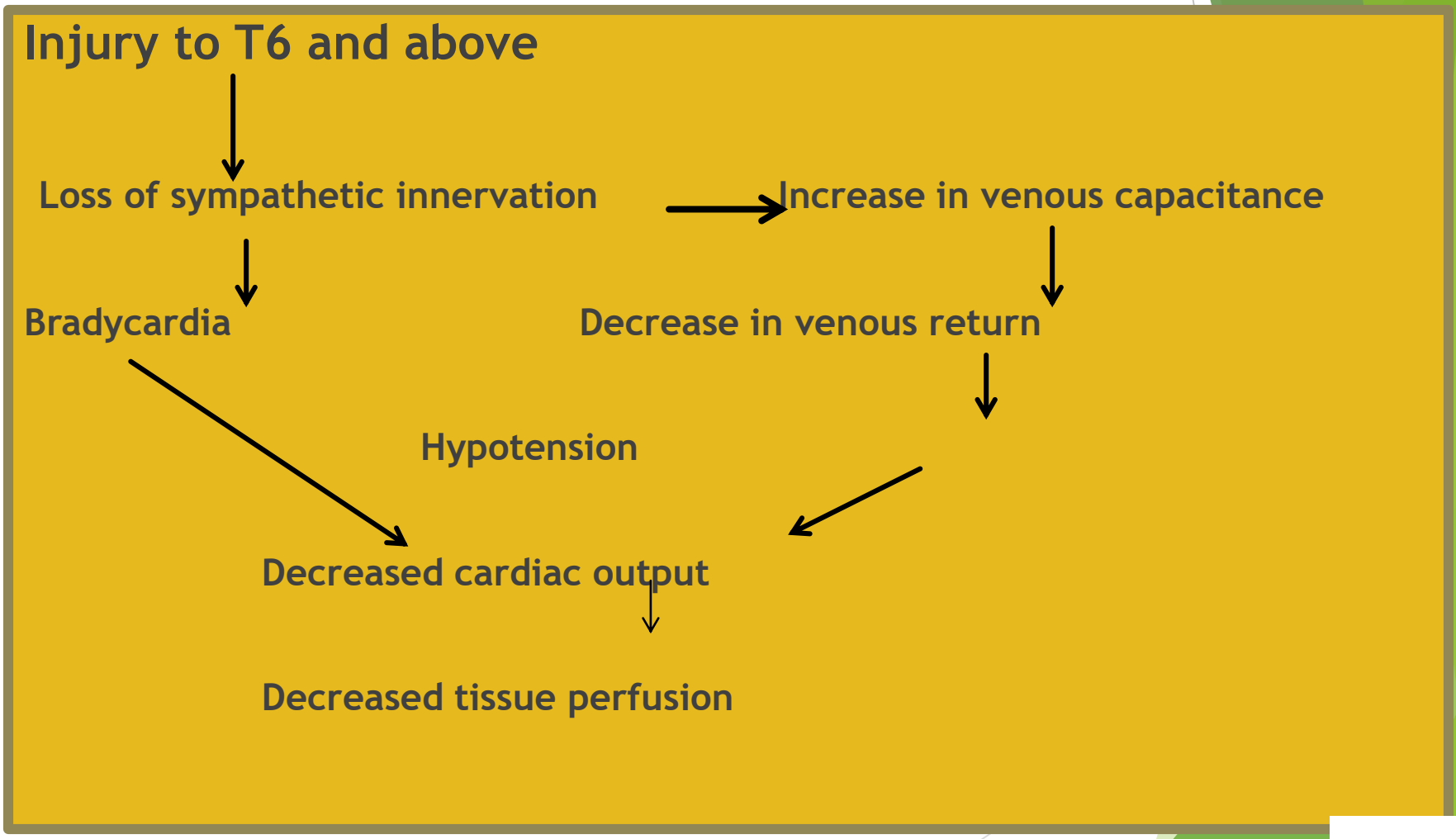
- **Airway**
  - C1-4 injuries require definitive airway
  - Injuries below C4 may also require airway due to
    - Work of breathing
    - Weak thoracic musculature
- **Breathing**
  - Adequacy of respirations
    - SpO2
    - Tidal volume
    - Effort
    - Pattern

Management

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

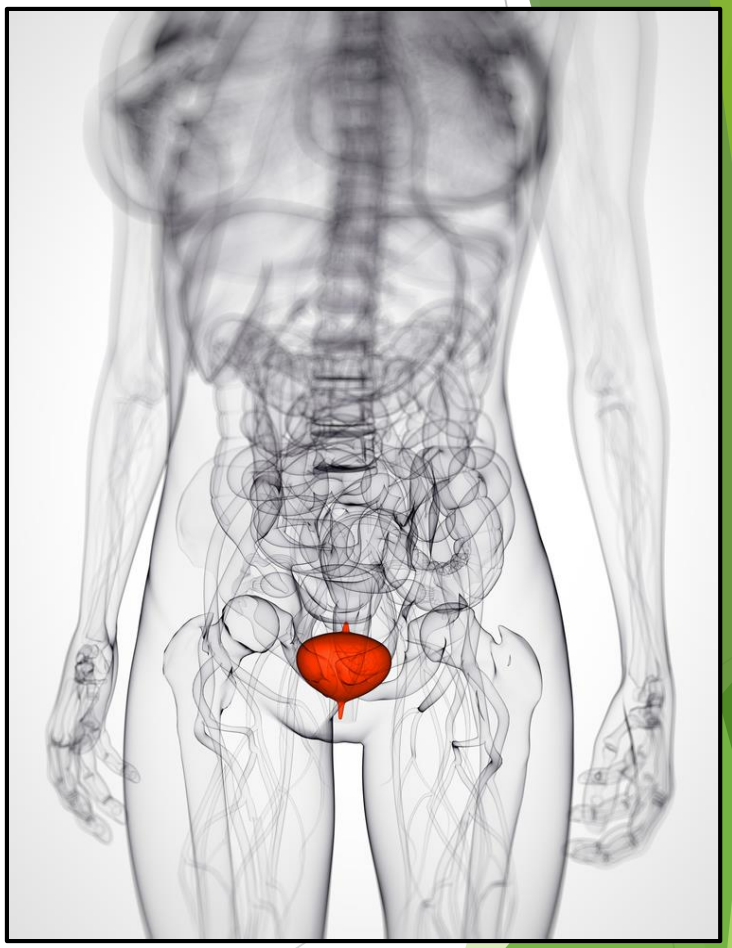


Neurogenic Shock



Management

- Urine output
  - Urinary retention
    - Atonic bladder
  - Foley
    - Initially avoid intermittent catheterization
    - High urine output from resuscitation fluids



Management

- Deficit
  - 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

Management

- 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
- Foster trust

Management

- **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, Monitor closely
    - Anecdotal papers
    - No peer reviewed/ class I clinical research studies to substantiate
  - High dose methylprednisolone
    - No longer considered standard of care

Management

- Pharmacologic agents
  - *Lazaroids (21-aminosteroids)*
  - *Opiate antagonists (Naloxone)*
  - *EAA receptor antagonists*
  - *Calcium channel blocker*
  - *Antioxidants and free radical scavengers*
  - Arachidonic acid inhibitors

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

Cervical Vertebrae

An unstable injury may require the use of cervical traction.
Equipment:
- Gardner-Wells tongs or Halo ring
- Weights
- Bed apparatus

Logroll

A wedge-turning frame or kinetic bed may be used for enhanced mobility

Thoracic and Lumbar Vertebrae

Standard bed
HOB flat
Logroll

If the injury is unstable, a wedge-turning frame or kinetic bed may be utilized for mobility

Cervical Orthoses (CO)

- Philadelphia collar
- Miami J collar
- Aspen collar
- NecLoc collar
- Stifneck collar
- Malibu brace

Head cervical orthoses (HCO)

- Halo ring with vest
- Minerva brace

Cervicothoracic orthoses (CTO)

- Yale brace
- Guilford brace
- SOMI brace
- Two-poster brace
- Four-poster brace

NOTE: for T6-T8 a combination of CTO and TLSO may be required for maximal support

Thoracolumbosacral orthoses (TLSO)

- Jewett brace
- James brace
- Custom molded rigid body jackets
- Custom flexible corsets

NOTE: for L4 and below a hip-thigh extension is added for support

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Management

- Rotational bed therapy
  - Maintain alignment and traction
  - Prevent respiratory complications of immobility

Management

- Surgical
  - 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
  - SSEP -during procedure to monitor changes
    - Limited to ascending sensory tracts esp.. dorsal columns

Complication Prevention

- **Respiratory**
  - Complications of immobility
    - Atelectasis, Pneumonia
    - Pulmonary embolism
  - Respiratory insufficiency/ failure
    - Level of injury affects phrenic nerve, intercostals
    - Increased work of breathing, fatigue
    - Rate and pattern are altered (accessory muscle use)
    - Monitor breath sounds

Respiratory

Ventilation

Early intubation to prevent hypoxia and fatigue

C1-4 injuries require tracheostomy and home ventilation training

Quad cough training

Communication tools

Bronchoscopy

Respiratory

- Pulmonary management
  - Weaning parameters
  - Monitor SpO2 and ABGs
  - Routine CXR
  - Aggressive pulmonary toilet
    - Postural drainage (PD)
    - Chest physiotherapy (CPT)
    - Kinetic bed therapy
  - Suctioning

Respiratory

- Non-ventilated patients
  - Pulmonary function tests
  - Incentive Spirometry
  - Non-invasive ventilation (CPAP, BiPAP)
  - Abdominal binder
  - Early OOB/ mobilization

Complication Prevention

- Cardiovascular
  - Neurogenic shock
  - IV fluids –includes vasopressors
  - Atropine or pacing ONLY when bradycardia symptomatic

Cardiovascular

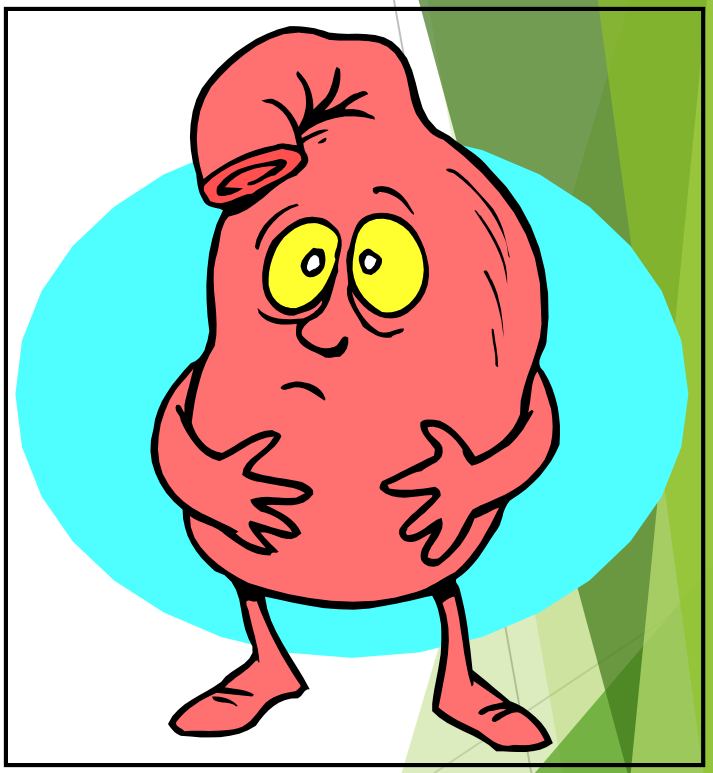
- Orthostatic hypotension
  - Decreased BP, possibly increased heart rate, dizziness or lightheadedness, blurred vision, loss of consciousness
  - Provide physical support with hose, abdominal binder; salt tablets; Florinef; sympathomimetics
  - Slowly raise the head of the bed for mobilization
  - Turn slowly
  - Prone to vasovagal response

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
    - Insensate skin

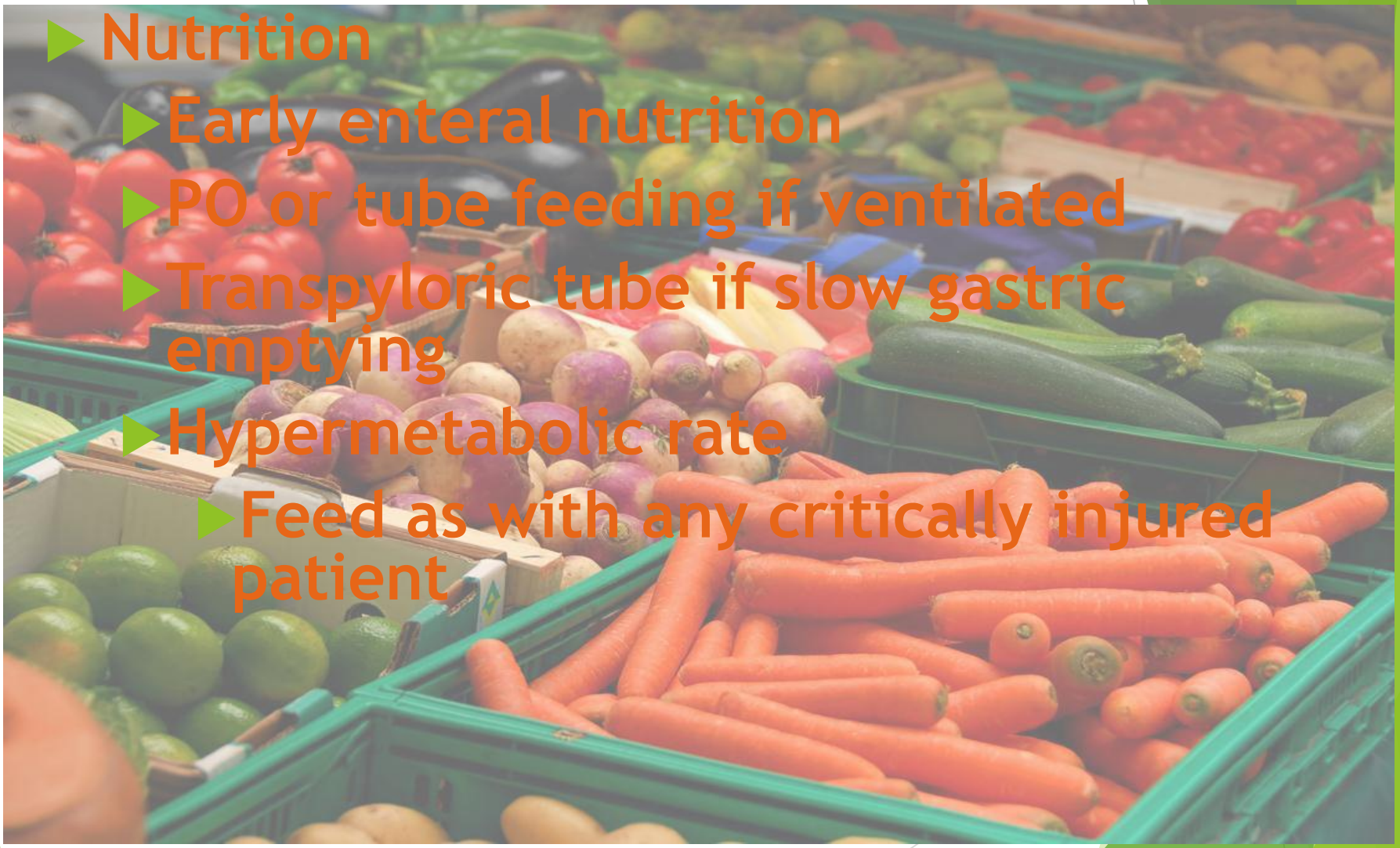
Complication Prevention

- 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



- 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

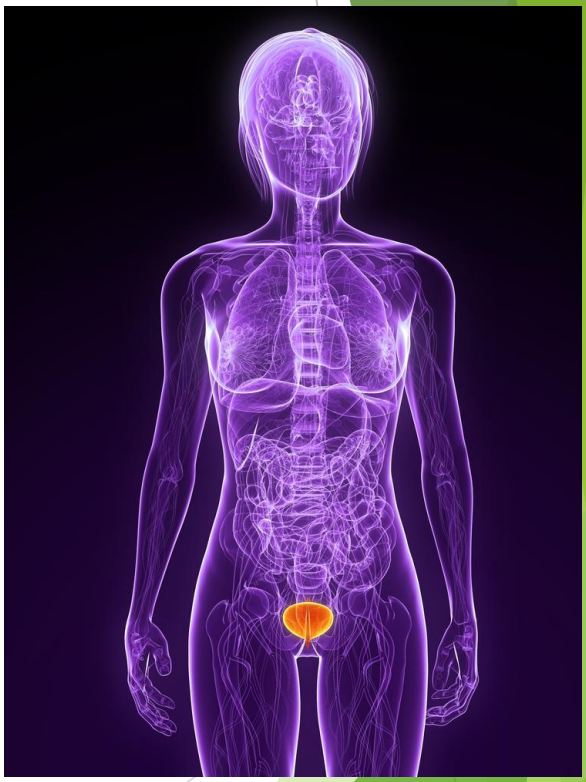
Complication Prevention

- Venous thromboembolism
  - Slightly higher risk the first 2-3 months post injury
  - Duplex ultrasonography evaluation
  - Prevention (x 3months)
    - 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

Complication Prevention

Reflexive bladder – involuntary contraction

- Fluid restriction transition to straight cath
- Condom catheters, SPT
- Palpate for fullness (approx 5-600ml/4-6hr)



Urinary

- **Areflexive bladder**
  - Valsalva or crede
  - Prone to incontinence/ skin issues
  - Condom catheters, incontinence pads, conduit
- **DSD**
  - Results in elevated voiding pressures
  - Annual urodynamic evaluation
  - 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

Urinary

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

Complication Prevention

Skin breakdown

- Pressure, insensate, dampness
- 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

Complication Prevention

Musculoskeletal

- Spasticity – flexor, extensor, alternating
  - Reduce venous pooling, stabilize thorax, aids in dressing and stand-pivot transfer
  - Chronic pain, contractures, heterotrophic ossification, skin breakdown
  - ROM, positioning, weight-bearing, splinting, pharmacologic management, surgery- neural severing (permanent)

Musculoskeletal

Heterotrophic ossification

- Ectopic bone within connective tissue
- Below spinal lesion
- More often complete injuries with spasticity
- Redness, swelling, warmth, pain, decreased R
  fever, positive bone scan

Musculoskeletal

Contractures

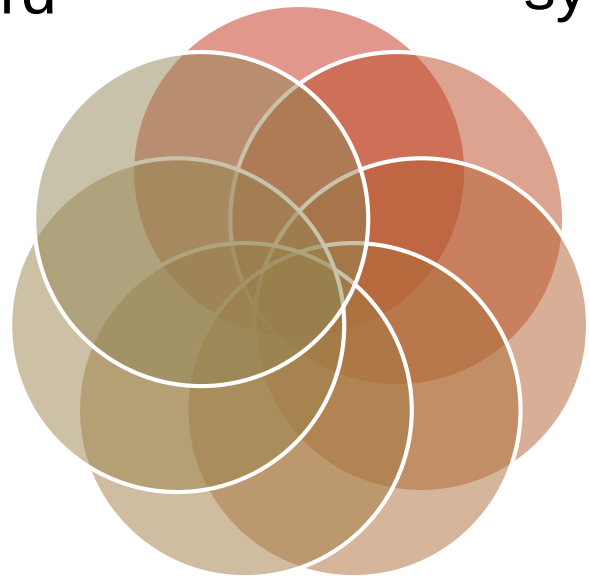
- Imbalance of muscle innervation
- High level cord injury, skin breakdown, concomitant head injury, spasticity, HO, fractures
- PREVENTION – aggressive ROM, mobilization, PT/OT, splinting, positioning, serial casting, anti-spasmodics

Complication Prevention

Neurologic - Post traumatic Syingomyelia

A fluid filled cavity which develops within the spinal cord

Most common symptom is pain



Surgical decompression

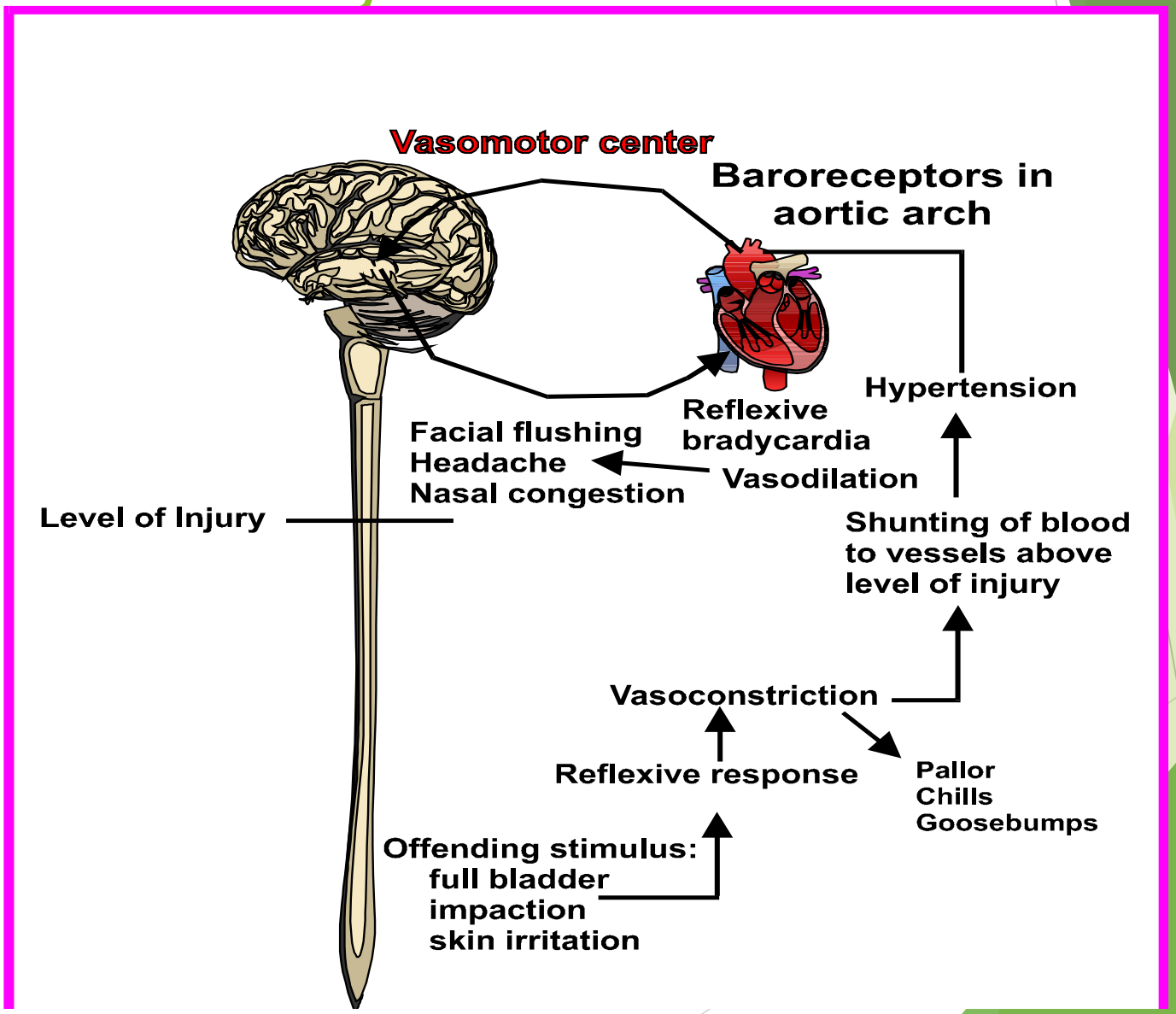
Serial monitoring via MRI

Complication Prevention

Autonomic dysreflexia

- An uncontrolled, massive sympathetic reflex response to noxious stimuli, below the level of the lesion
- Precipitating factors
  - Full bladder
  - Distended bowel
  - Skin irritation, ingrown toenail
  - UTI
  - Uterine spasms, penile stimulation
  - Tight clothing, wrinkled sheets

Autonomic Dysreflexia



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
- Administer anti-hypertensives if the above fails
- Education –family and patient

Psychologic

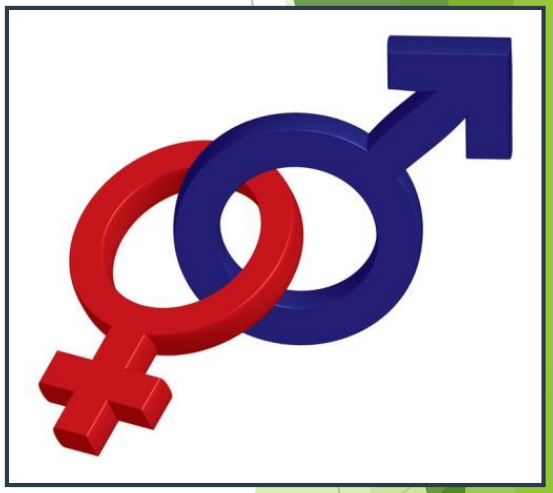
Pain/Depression

- Nocioceptive – noxious stimuli to normally innervated parts
- Neurogenic – nerve tissue injury in CNS or PNS
- Evaluate for depression associated with pain
- 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

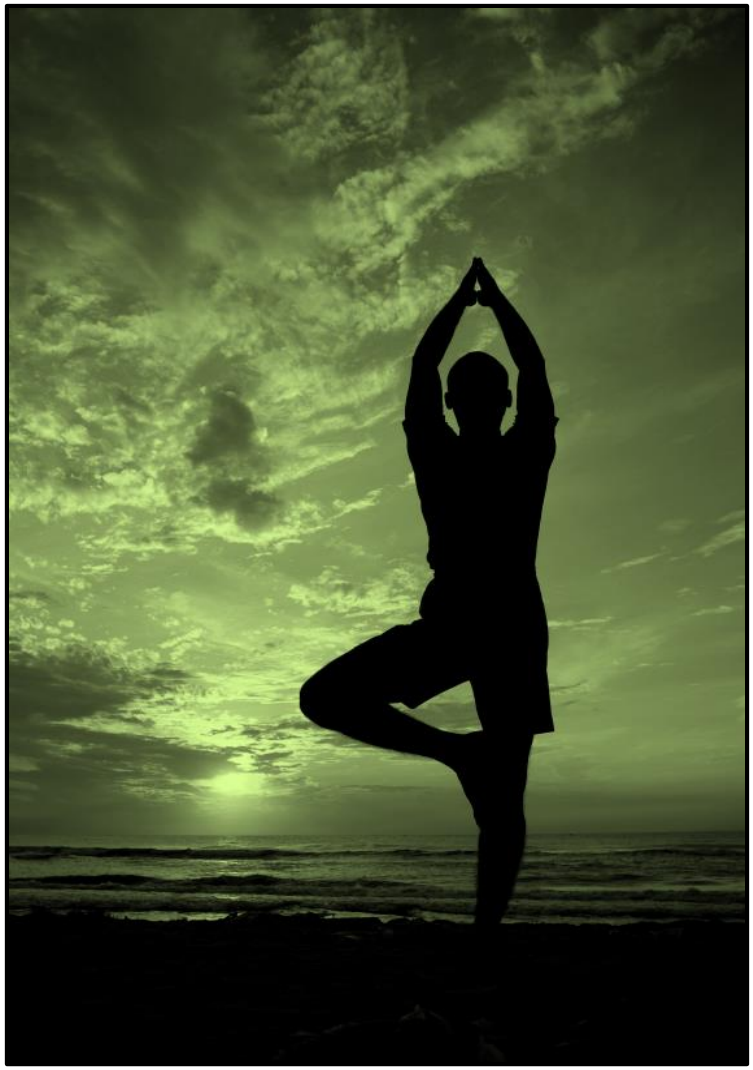


Sexuality

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



- Mobility
  - Tendon transfer
  - Functional electrical stimulation
  - Lower level of injury, more functional
- Bowel and Bladder Management
- Prevention of complications

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 without long term effects
- Spinal cord injury requires diligence in complication prevention