



## 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



Briefly review objectives

## 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



The most common causes of death

- pneumonia and sepsis

NO new incidence studies in the US since the 1990's

The National SCI database (since 1973, approx 13% of all new SCI in the US)

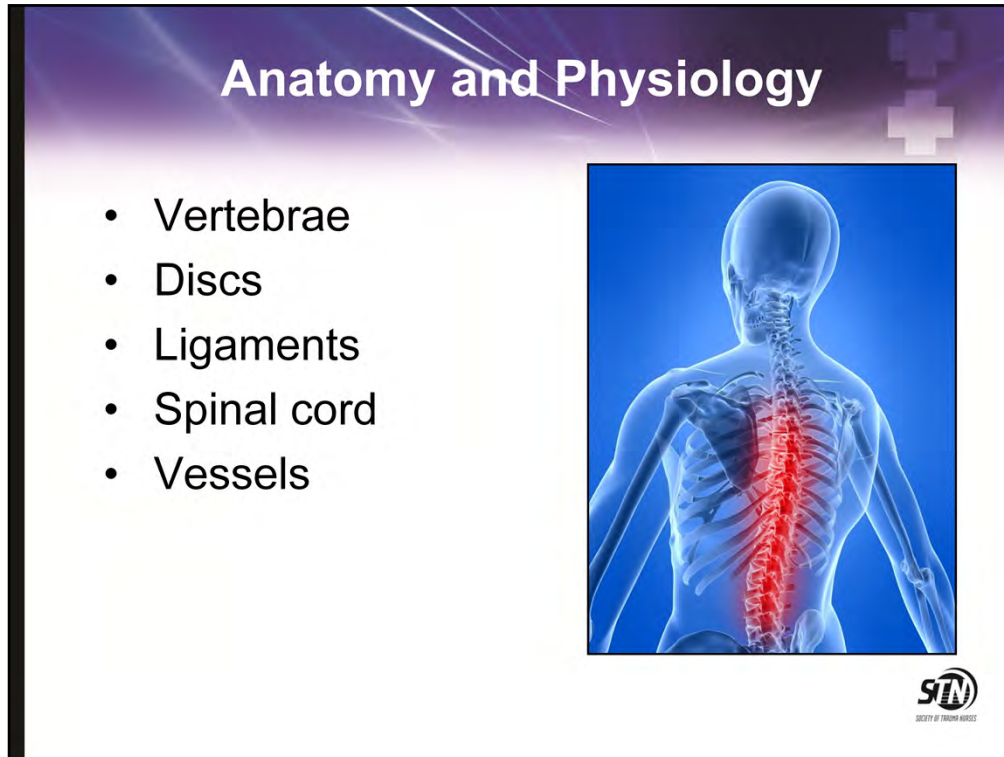
- Hispanics increased from 6% to 8% since 2005
- Increase incomplete tetraplegia 40%; next most common complete para 22%
- Less than 1% have complete recovery prior to discharge from the hospital
- Average hospital LOS 12 days; average rehab LOS 37 days
- Increase in violent events as cause

Life expectancy improves after the 1<sup>st</sup> year survival

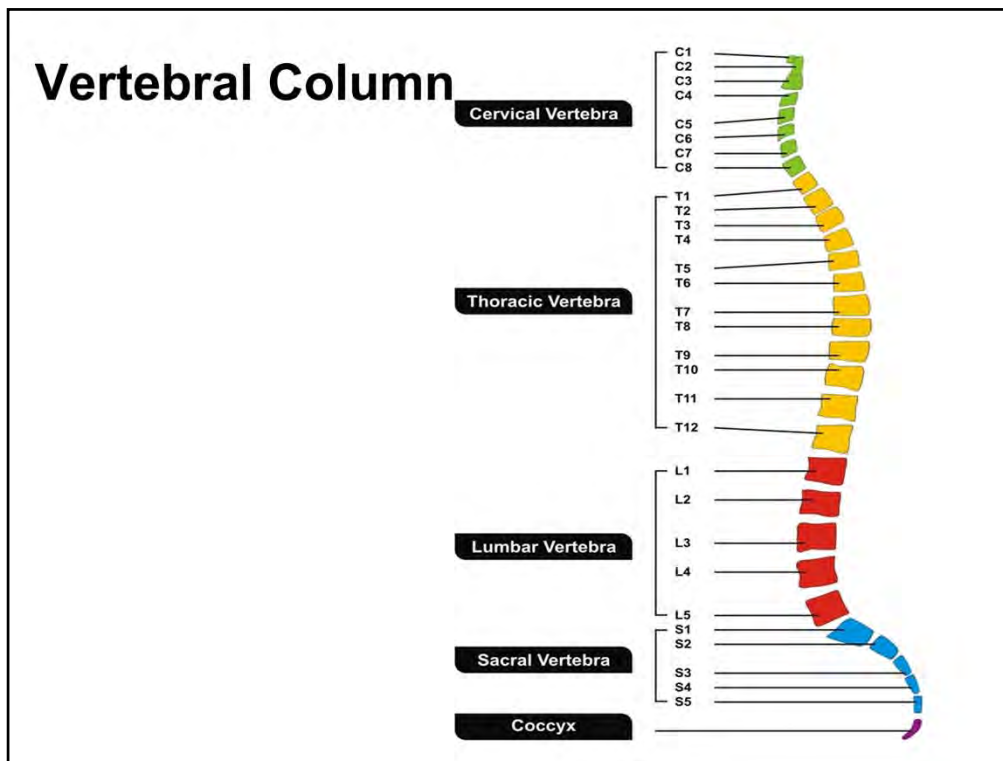
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[www.spinalcordinurystatistics.com](http://www.spinalcordinurystatistics.com)

[www.fscip.org/facts.htm](http://www.fscip.org/facts.htm)

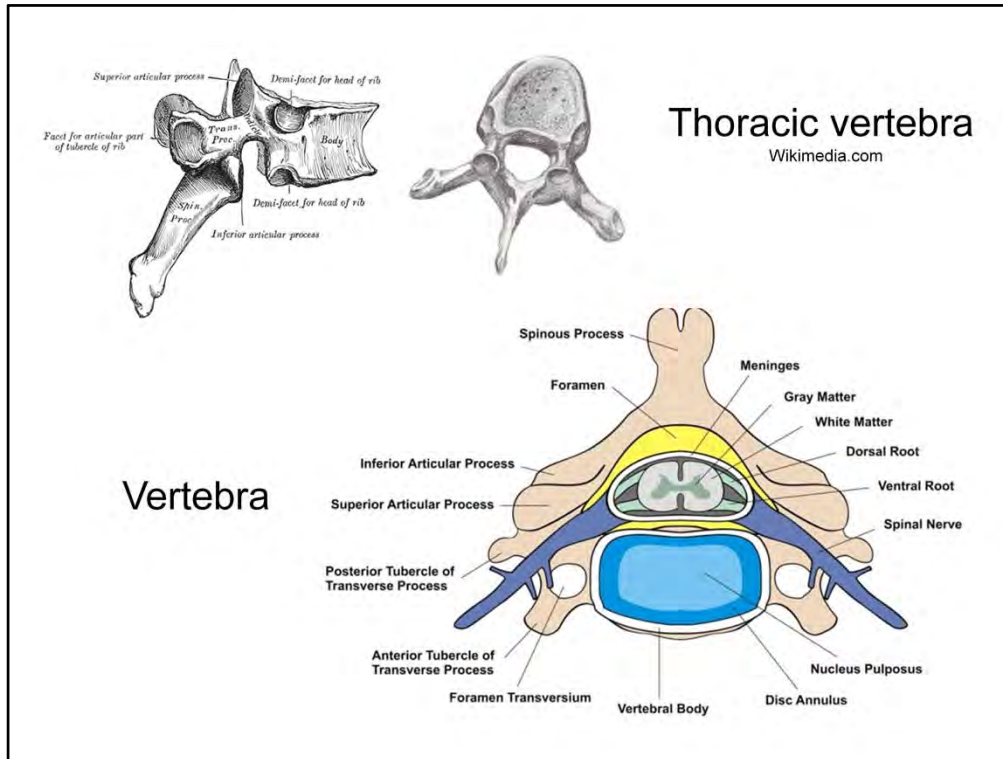


- Spinal column consists of 33 vertebrae with spongy discs in between to provide flexibility, absorb energy and cushion the bones during everyday activities; both the sacrum and coccyx are part of the pelvis
  - 7 cervical
  - 12 thoracic
  - 5 lumbar
  - 5 sacral (fused)
  - 4 coccyx (fused)
- Ligaments support the spine both anteriorly and posteriorly; most instability relates to the degree of ligamentous damage; injury to the ligaments allows movement of the vertebrae that may impinge on the spinal canal
- Spinal cord itself is housed within the vertebrae with nerve roots exiting the bones at each level; the cord ends at L1-L2 forming the cauda equina – the nerves roots feeding the lower extremities and perineum; note there are 8 cervical roots for the 7 cervical vertebrae
- Anterior and posterior spinal arteries feed the cord; an injury to these vessels or to the main vessels feeding these will result in ischemia to the cord and resultant loss of function

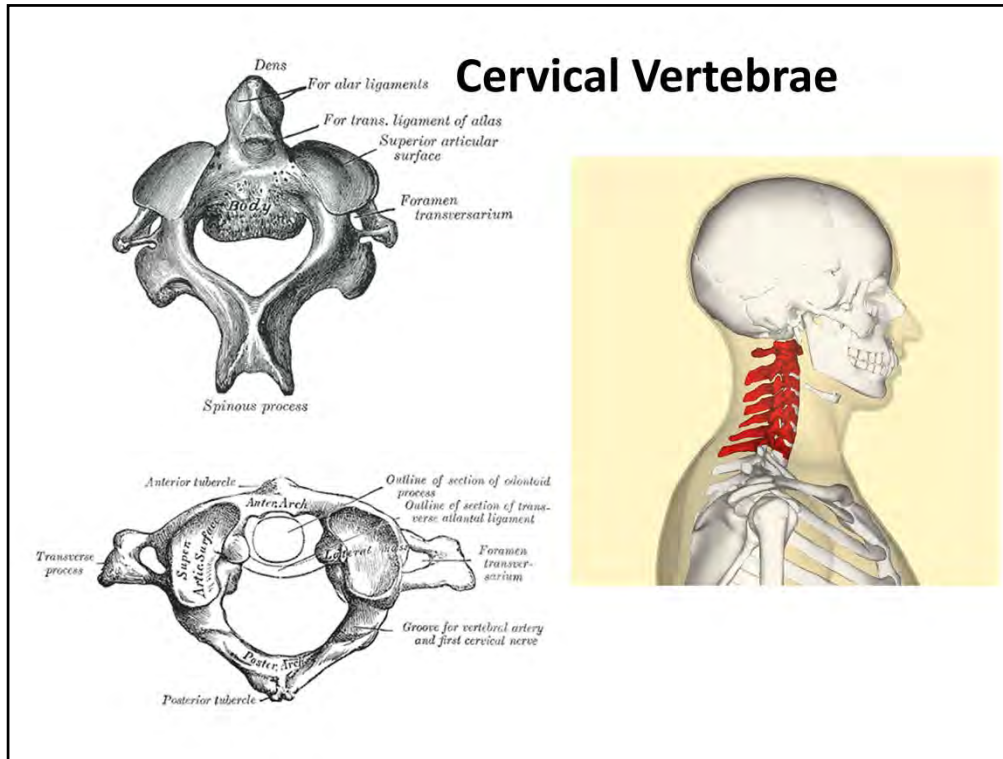


- Note that there is natural curvature to the spine
- Loss of the normal lordosis indicates ligamentous injury



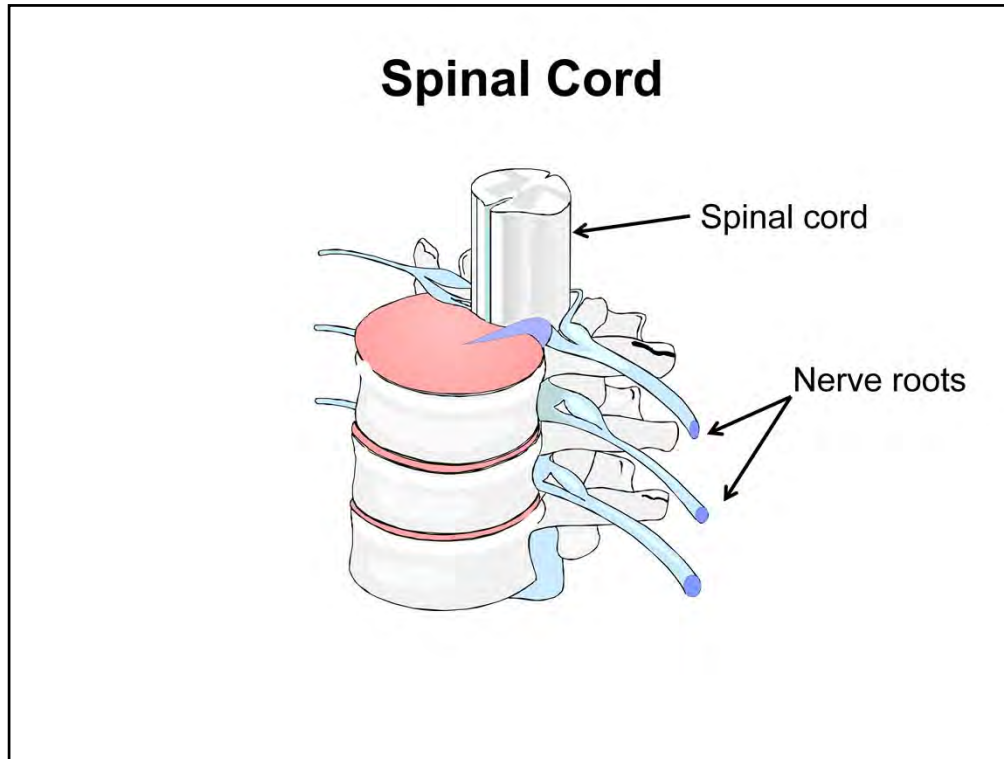


- Note the shape of the majority of the vertebrae; the central area is for the spinal cord
- The transverse processes are longer in the thoracic spine to allow for the attachment of the ribs
- The vertebral body gets larger for the lower vertebrae providing support
- The facets are like thumbprints onto which the cephalad vertebra articulates



- C1 (atlas) is a ring which articulates with the occipital condyles (atlas)
- C2 (axis) is shaped as all the other vertebrae except for the odontoid (dens) which is a finger-like structure around which C1 sits allowing the head to rotate
- Note the increase in length of the spinous processes down to C7

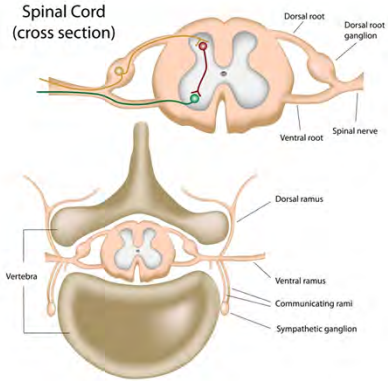




- Spinal cord and 31 pair of nerve roots are protected by the bony structure and each root exits between each vertebra at the intervertebral foramen
- The spinal cord is an extension of the medulla oblongata
- The termination point is called the conus medullaris
- Divided into central gray and surrounding white matter
  - The dorsal component is the sensory fiber (afferent) and the ventral root is the motor fiber (efferent)
  - This distribution becomes important in understanding the sensorimotor findings in injury
- Covered by meninges
  - dura, arachnoid and pia mater
- Spinal nerves exit at each vertebral level in “pairs”

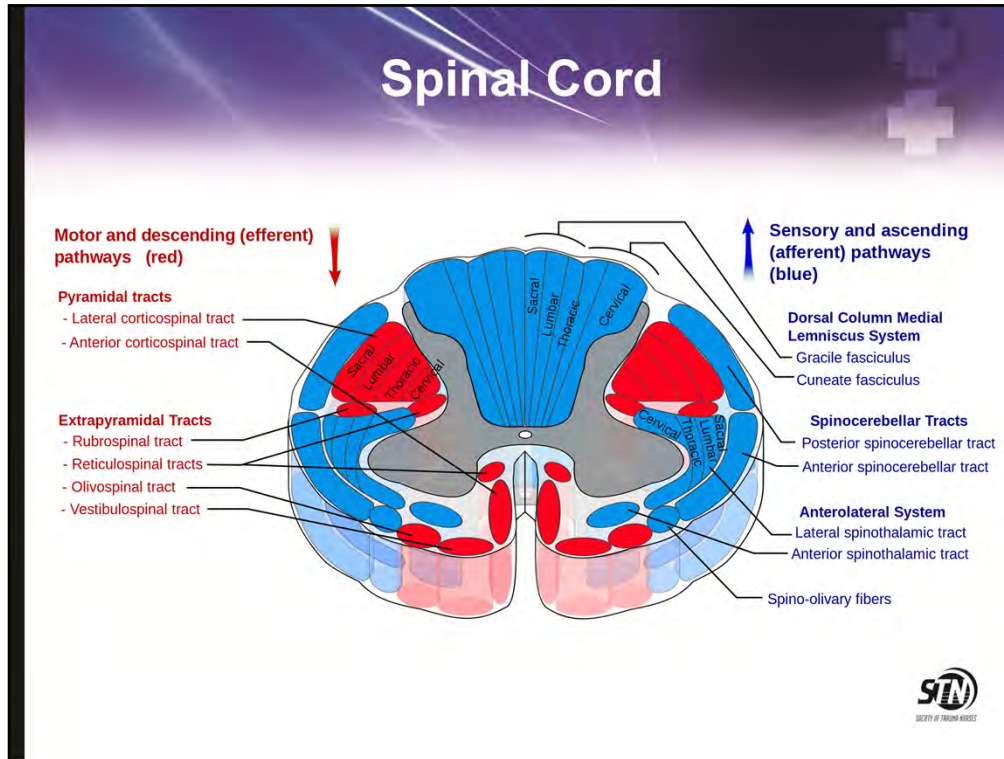
## Anatomy and Physiology

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



**STN**  
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- Gray matter = cell bodies, axons, dendrites; 3 horns
  - Anterior – motor (final common pathway)
  - Intermediolateral- preganglionic sympathetic fibers T1-L2; parasympathetic L3-4
  - Posterior – peripheral sensory neurons
- White matter = large fiber bundles are columns with ascending sensory and descending motor tracts ( 3 horns)
  - Anterior- motor function, light touch, pressure
  - Lateral – 8 tracts
    - Spinocerebellar (position sense, movement for coordination)
    - Spinothalamic (information to the thalamus)
  - Posterior- position sense (proprioception), vibration, 2 point discrimination, touch, deep pressure



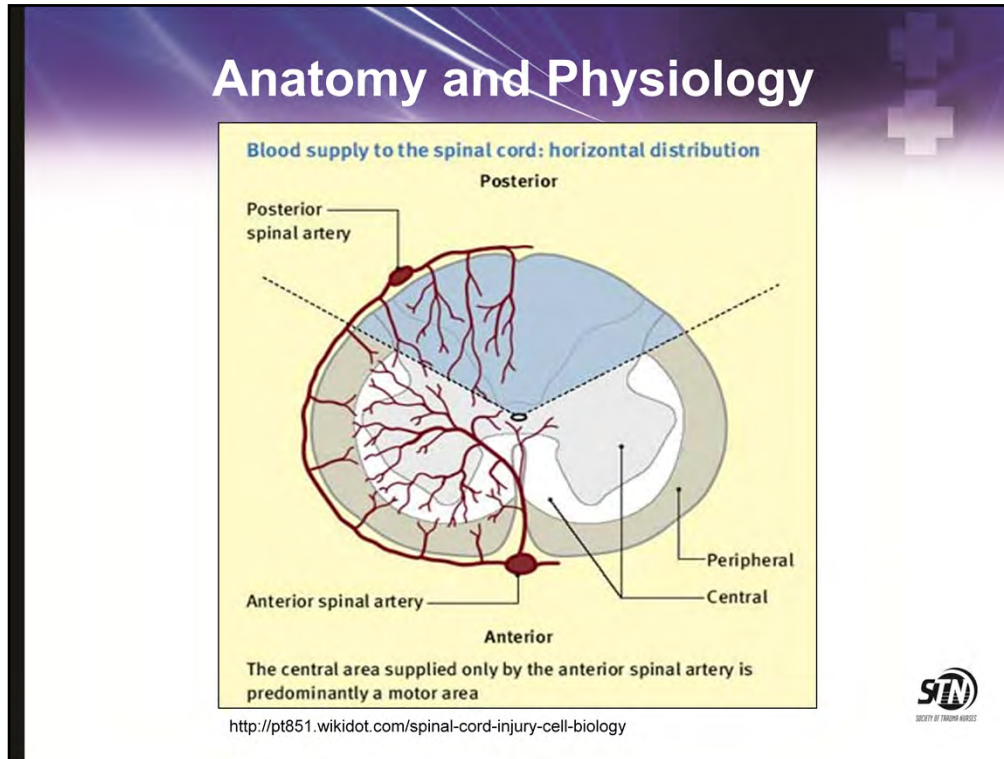
- Remember the arrangement- motor anterior and sensory posterior
- Descending carry information from the brain to the body
- Ascending brings information to the brain
- Major descending – corticospinal, reticulospinal, vestibulospinal
  - Lateral corticospinal (pyramidal tracts) largest and clinically most important
  - These tracts originate in the motor cortex and decussate or cross over at the level of the medulla and continue along the column. They are arranged so that the fibers innervating the legs are most peripheral and those innervating the arms are medial/central. This arrangement becomes significant during injury.
- Upper motor neuron – remains within the central nervous system
- Lower motor neuron- motor neurons (final common pathway)

## 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



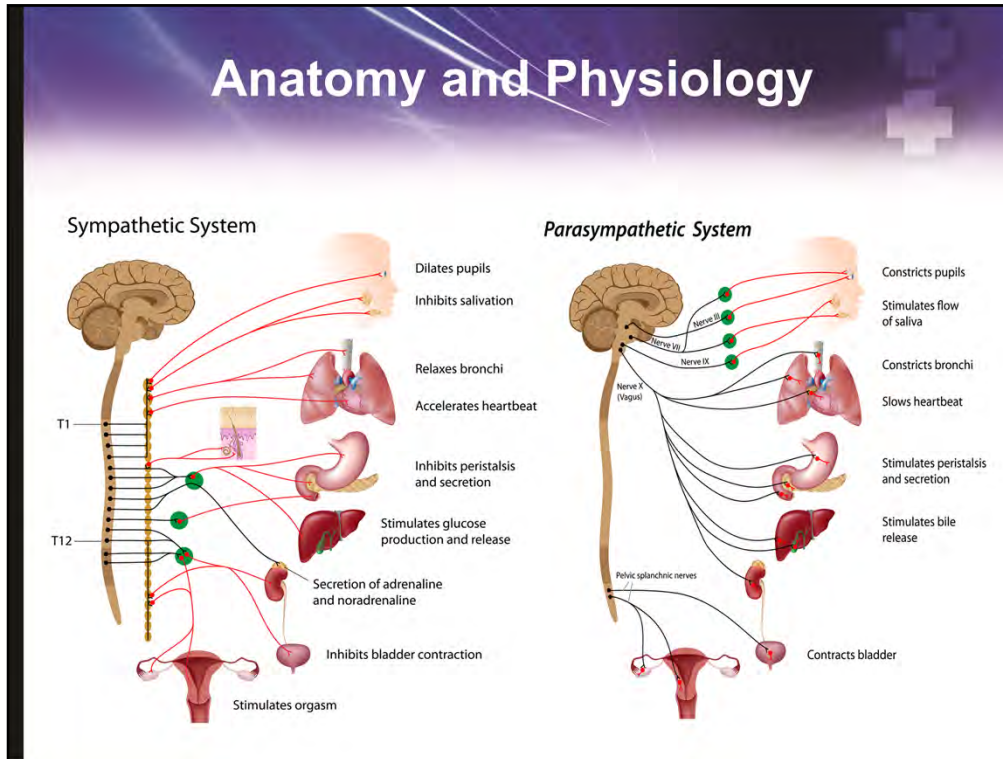
- Upper motor neuron- within the spinal cord and results in profound injury
- Lower motor neuron – terminates in the muscle fibers; anterior horn cells and their motor neuron
  - These tracts are in the gray matter, the anterior horn
  - All Lower Motor Neurons are influenced by Upper Motor Neurons
- Disruption to the LMN produces the opposite affect of the UMN disruption



### Spinal Arteries

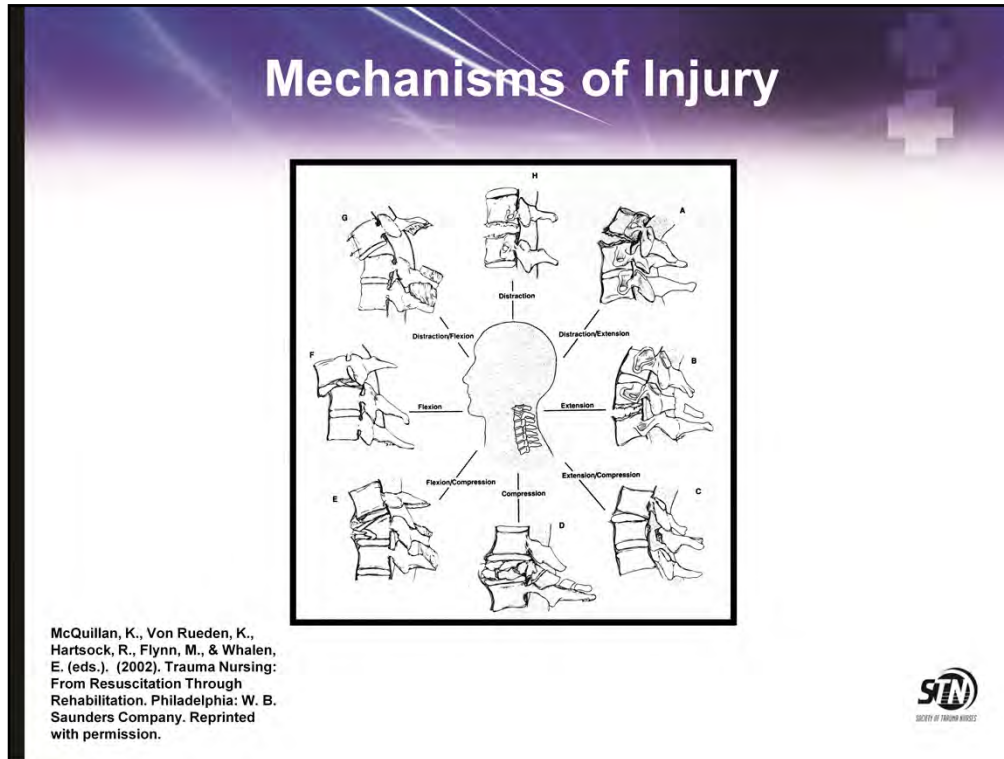
- Terminal branches of the vertebral artery unite to form the spinal artery
- Critical to spinal cord blood flow is that the major arterial supply arises from the anterior spinal artery which feeds the **anterior two thirds** of the spinal cord
- Disruption to the spinal artery will produce significant ischemia of the spinal cord substance where the motor tracts are arranged





- Autonomic nervous system – regulates function of involuntary muscles and glands; controlled by hypothalamus
  - Sympathetic – fight or flight
  - Parasympathetic – homeostasis/balance
    - Majority exit C1





Common mechanisms of injury include

- Hyperflexion – most commonly diving and striking the top of the head on the bottom
  - Disrupts posterior elements and may include spinal cord
- Hyperextension – frequently a fall striking the chin on an object on the way down
  - The anterior ligament is stretched and may tear
  - Discs may rupture
  - Subluxation or the sliding of one vertebrae over another
  - Force is also applied along the posterior elements, especially the spinous process and lamina, possibly producing fracture
  - Central cord contusion
- Axial load (vertical compression) – fall from height – vertebral body compression

This represents the mechanisms of injury and demonstrates how they can occur in isolation or in combination

Visualize the impact and the direction the forces will take along the spinal column to understand the involvement of discs, ligaments, and patterns of fracture

## Initial Management

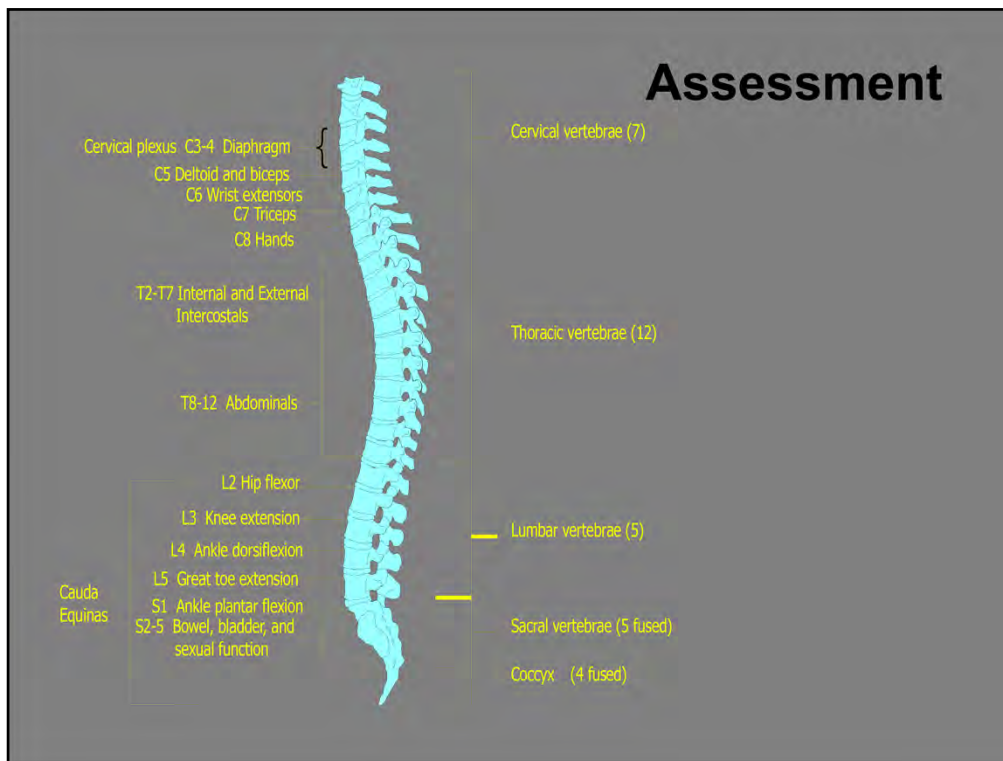
Pre-hospital

Resuscitation

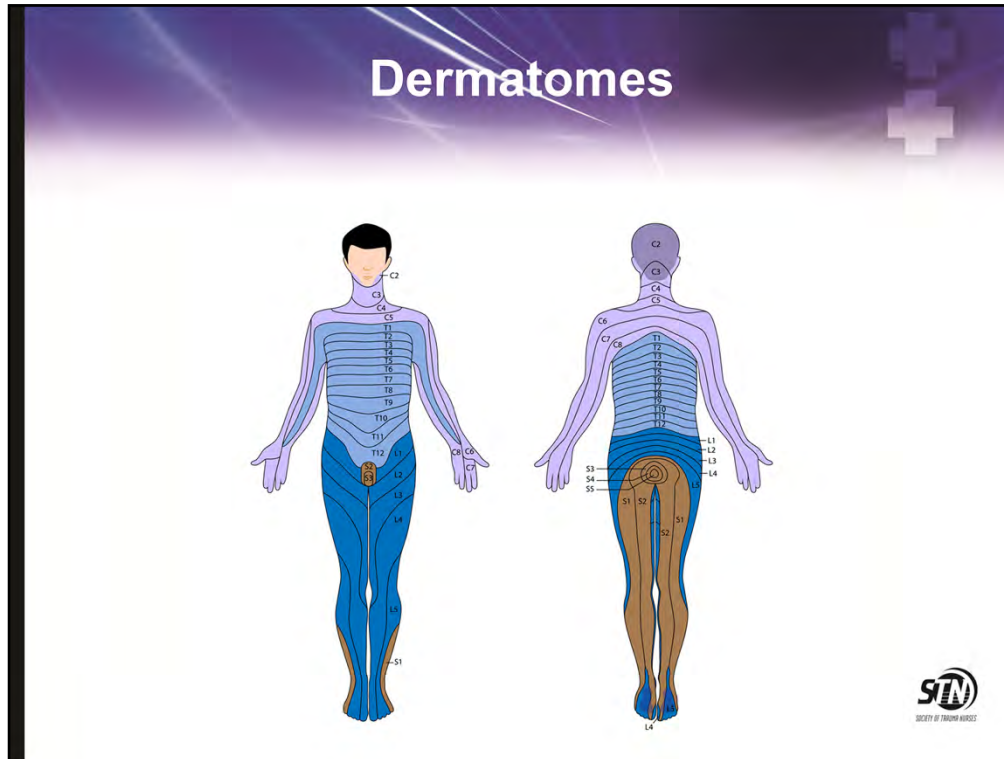




- EMS – Story of the event, assume injury
  - assume spinal cord injury and protect the spine by placing cervical collar, backboard, head blocks strapped to the board; extrication
  - Maintain blood pressure and oxygenation to prevent secondary injury
  - Assess alterations in movement and/or sensation from the time of the event
  - Obtain the history of event – ejection? Helmet? Speed? Seatbelt? Proper child restraint- front or back seat?
- Resuscitation – continue to protect the spine until proven uninjured; remove the backboard and logroll to protect the spine; maintain cervical collar
  - Prevent hypotension and hypoxia
  - Full assessment
- **What is your policy for backboard removal? When you log roll to assess the back? After C-spine is “cleared”?**

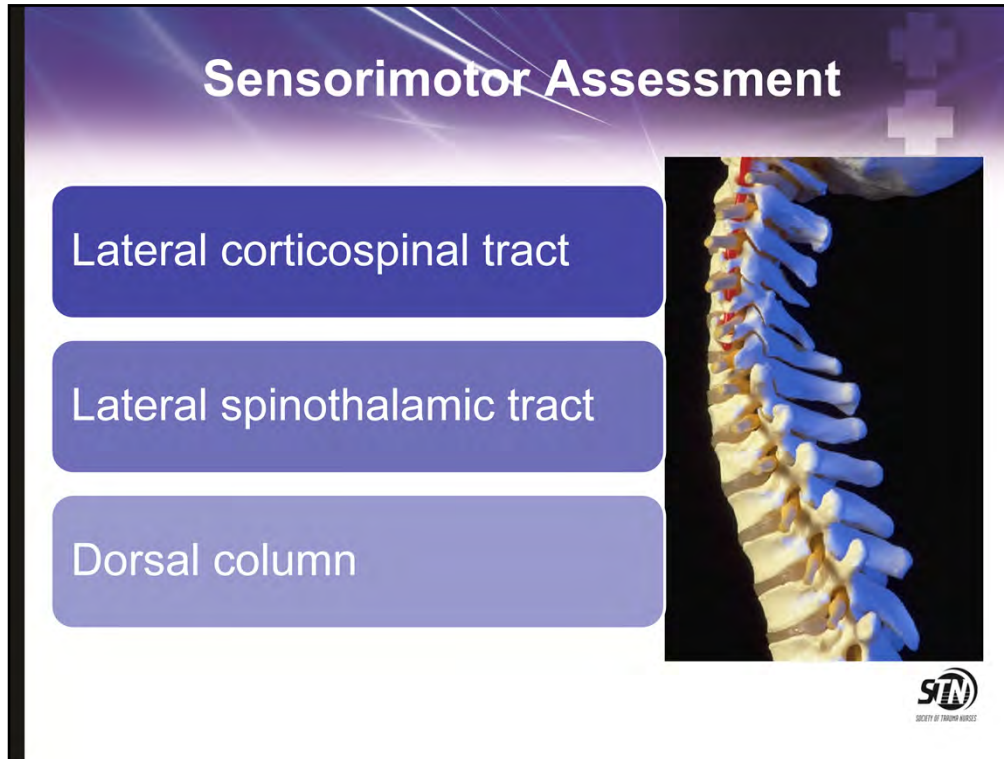


- Each level of the spinal cord has a corresponding sensory and motor evaluation
- Starting at the head and working caudally a bilateral exam is performed
- Cervical spine highest level of motor function and fine motor control – assess nerve roots
  - C1-4- respiration (phrenic nerve)
  - C5- elbow flexion
  - C6- wrist extension
  - C7- elbow extension
  - C8- finger flexion
  - T1- finger extension
- Thoracic spine, assess inspiration and **forceful** expiration
  - Place your hand on the thorax and also observe breathing mechanics
  - Watch for paradoxical pattern of chest and abdomen which may indicate impairment of abdominal musculature function
- Lumbar spine
  - L1-2- hip flexion
  - L3 (cauda equina)- knee extension
  - L4- ankle dorsiflexion
  - L5-great toe (#1) extension
- Motor score –
  - 0 No visible or palpable movement
  - 1 Visible or palpable movement; flicker
  - 2 Active movement gravity eliminated
  - 3 Active movement against gravity
  - 4 Active movement against resistance
  - 5 Normal



Dermatomes – sensory patterns of the body

- Note that C5 sensory pattern forms a shawl collar on the anterior thorax – often confuses the practitioner into thinking it is a T1 sensory level when it is actually C5 (which should also match the motor exam)
- There are 28 dermatomes
  - Each individual distribution needs to be evaluated on the right and left sides of the body
- Both pinprick and light touch should be tested and scored from
  - 0 for absent
  - 1 for abnormal (impaired or paresthetic)
  - 2 for normal
- If an area is untestable, “NT” should be documented



- Close eyes for sensory discrimination and proprioception so that visual cues do not alter their responses
- In the patient with spine injury, the desire to be normal is so high, “cheating” may occur –resulting in inaccurate assessments

Lateral corticospinal tract

Grade all muscle movement bilaterally and compare

Lateral spinothalamic tract


Determine discrimination between sharp-dull for each dermatome

Dorsal column

Proprioception – digit position up/down

## Reflex Assessment

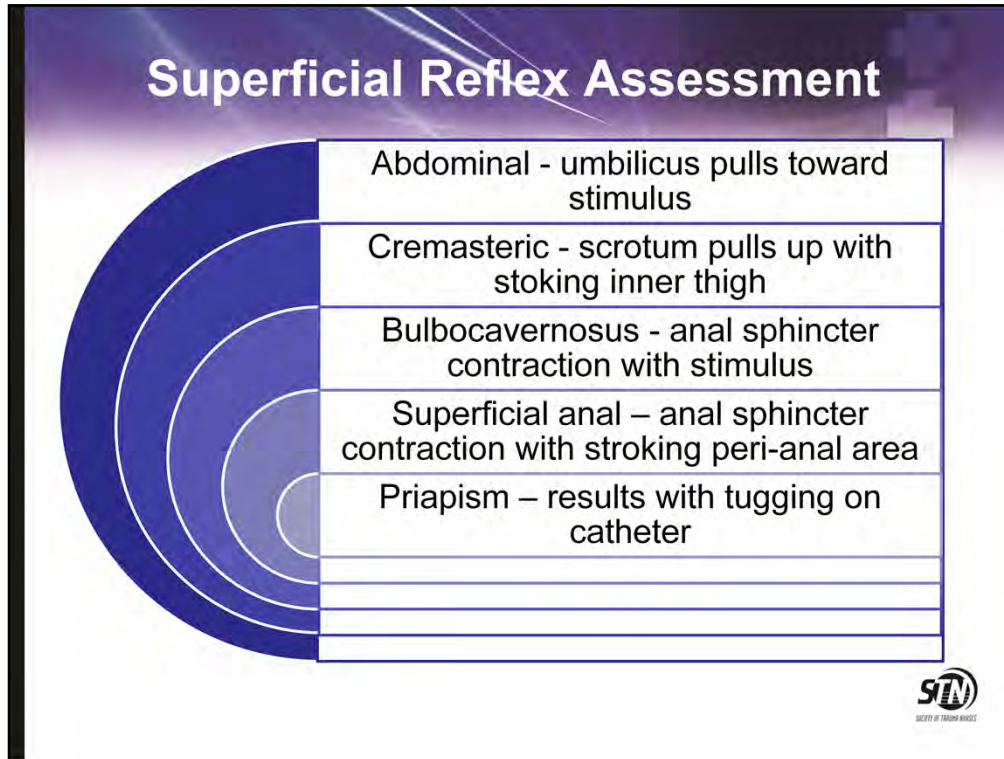
- Test for sensory/motor sparing
- Major deep tendon reflexes (DTR) assessed
  - Biceps (C5)
  - Brachioradialis (C5-6)
  - Triceps (C7-8)
  - Quadriceps (knee-jerk) (L3-4)
  - Achilles (S1-2)
- Scoring 0 to ++++



The diagram shows a black silhouette of a human figure with arms raised and legs apart. There are eight pairs of '++' symbols placed around the silhouette: two pairs on the upper arms, two pairs on the upper legs, and two pairs on the lower legs. In the bottom right corner of the diagram area, there is a logo for STN (Society of Trauma Nurses) with the text 'SOCIETY OF TRAUMA NURSES' below it.

- Document as in the diagram above
- Reflex testing helps determine sensory or motor sparing and approximate level of injury
- Specific nerve roots innervate each reflex
- Reflexes are categorized as deep tendon or superficial
- DTRs are rated from 0 to 4+ with “2” being normal
  - 0 – no response
  - + diminished
  - ++ normal
  - +++ brisker than normal
  - ++++ hyperactive (clonus)






- Abdominal – stroke upper and lower abd
- Cremasteric
- Bulbocavernosus – squeeze glans penis or clitoris
- Superficial anal
- Priapism –also common at the time of initial injury; tugging on the catheter or pubic hair results in priapism as well



- Primary is a direct result of trauma
- Secondary is a result of decreased perfusion or oxygenation to the site of injury

## 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





SCI can also be classified by type of injury and the impact on function

- Pathophysiology of injury and outcome
- American Spinal Injury Association (ASIA) categorizes injuries as complete vs.. incomplete and clinical syndromes
- Specific syndromes in the following slides

## Cord Syndromes

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





Central Cord Syndrome (CCS) is the more common of the incomplete syndromes (central cord compression C3-4 seen here on MRI)

- 15-25% of incomplete injuries
- Most commonly in older persons with cervical spondylosis and/or stenosis
- Result of hyperextension producing forces both anteriorly and posteriorly on the spinal cord with an inward bulging of the ligamentum flavum
- Rarely involves fractures
- Disproportionate motor impairment in the upper extremities compared to lower extremities, bladder dysfunction, and varying sensory involvement
- **Generally** has a good prognosis for recovery
- Involves spinothalamic and corticospinal tracts for Upper Extremities

## Cord Syndromes

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



### Anterior cord syndrome

- Usually occurs as the result of
  - Strong flexion/compression forces exerted on the anterior spinal elements producing herniation of disc material or bone fragments into the anterior spinal cord substance
  - Occlusion/interruption of the spinal artery which feeds the anterior two-thirds of the spinal cord substance
- Motor function, pain, temperature and gross touch sensation is lost
- Proprioception, vibration, two point discrimination and stereognosis remain intact
- Loss of corticospinal and spinothalamic tracts
- **Image is a flexion injury from a car vs. tree collision.**



## 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

**Brown-Séquard Syndrome**



Image found on Wikimedia.org

- Transverse hemisection of the cord
- Unilateral penetrating trauma such as a stab wound or a fracture/dislocation of a unilateral articular facet
- Ipsilateral loss of motor, proprioception, vibration two-point discrimination and stereognosis
- Contralateral loss of pain, temperature, and gross touch sensations
- Represents the differing levels of decussation for the corticospinal and posterior column tracts (level of the medulla) and the spinothalamic tracts (within the cord prior to ascension)
  - Descending tracts decussate high, therefore, their disruption is ipsilateral
  - Ascending tracts cross over on the way up, therefore, their disruption is contralateral



## 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




Conus - Injury to the lumbar and sacral cord segments at the base of the cord and nerve root segments

- Combination of lower motor neuron deficits including flaccid paralysis, muscle atrophy, bowel and bladder deficits and variable sensory deficits


Cauda Equina, “the horse’s tail”, is an injury to the lumbosacral nerve roots often produced from fracture/dislocations

- Lower motor neuron deficit as it occurs below the termination of the spinal cord
- Complete or incomplete, unilateral or bilateral
- Potential for improvement if root not completely transected

## 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



Complete cord injury is usually evident immediately at the time of mechanism and is either quadriplegic or paraplegic depending on the level of injury



Complete cord can be due to contusion (which may have some resolution) or laceration/transection which cannot repair itself

Signs and symptoms include

- Loss of motor, sensation, pain, temperature, pressure, vibration, proprioception
- Loss of reflexes
- Loss of autonomic function – esp. above T6
- Loss of bowel and bladder
- Priapism
- Tachypnea if cervical or high thoracic injury

## 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



- Literature supports that only symptomatic patients require radiological evaluation
- Most common radiological studies performed in spinal injuries are the A/P, lateral C spine with odontoid views and the lateral and A/P views of the thoracic and lumbar spine
  - Readily available and portable
  - Rapid information about alignment and obvious fracture
  - Limited by body habitus and requires visualization of C7-T1
- CT scans provide a close look at bony structures and disc integrity
  - In general are replacing plain films for diagnosis
- 3D reconstruction views provide detailed information esp. to evaluate for surgical procedures
- MRI provides distinct images of the spine
  - Bony column, discs and ligaments and most importantly, the spinal cord itself
  - Allows physicians to visualize the extent of cord damage as well as column stability (ligaments)

## Diagnostics

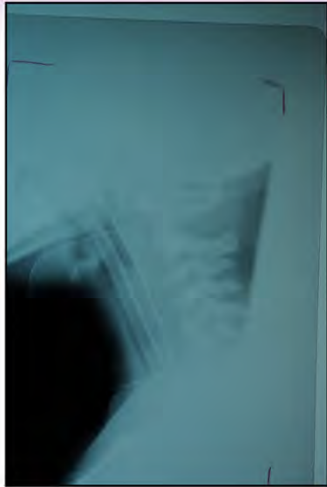
- Clearing the Cervical Spine
  - Awake, alert, and oriented
  - NO distracting injuries
  - NO drugs or alcohol that alter experience
  - NO pain or tenderness
- Clearing spine with films, CT, MRI
  - Complaints of neck pain
  - Neurologic deficit
  - Altered level of consciousness, ventilator




Hoffman et al 2000 NEXUS criteria for clearing the cervical spine

- Follow requirements specifically
- Most patients are without any pain or tenderness and once cleared of alcohol or drugs, can be cleared by the surgeon or emergency physician and the collar removed
- If pain, deficits, or altered level of consciousness is present, maintain the cervical collar until plain films, CT, and/or MRI demonstrate that there is no injury
- The collar may be maintained for comfort; follow cervical collar management to prevent skin breakdown

## 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





- Not all column fractures are associated with cord injury
- If there is one fracture, suspect another until ruled out by films
- Simple fractures (spinous processes, transverse processes) without ligamentous injuries are considered stable and may require a simple orthosis for management
- Complex fractures, dislocations, and/or ligamentous injuries may require not only an orthosis, but surgery as well
- A-O = C1-occiput dislocation – frequently kids due to the size and weight of the head and undeveloped ligaments
- A-A = C1 on C2 dislocation (**seen here – tricycle rider struck by slow moving vehicle, immediate and complete quad w/ respiratory arrest**)
  - Both AA and AO can survive (but as ventilator dependent high quads) if **provided a rapid airway**



## Fractures-Dislocations

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



- C5-6 point of greatest flexion of the neck and most likely injured
- C2 dens fx frequently in elderly with hyperextension injury

Type I (tip)

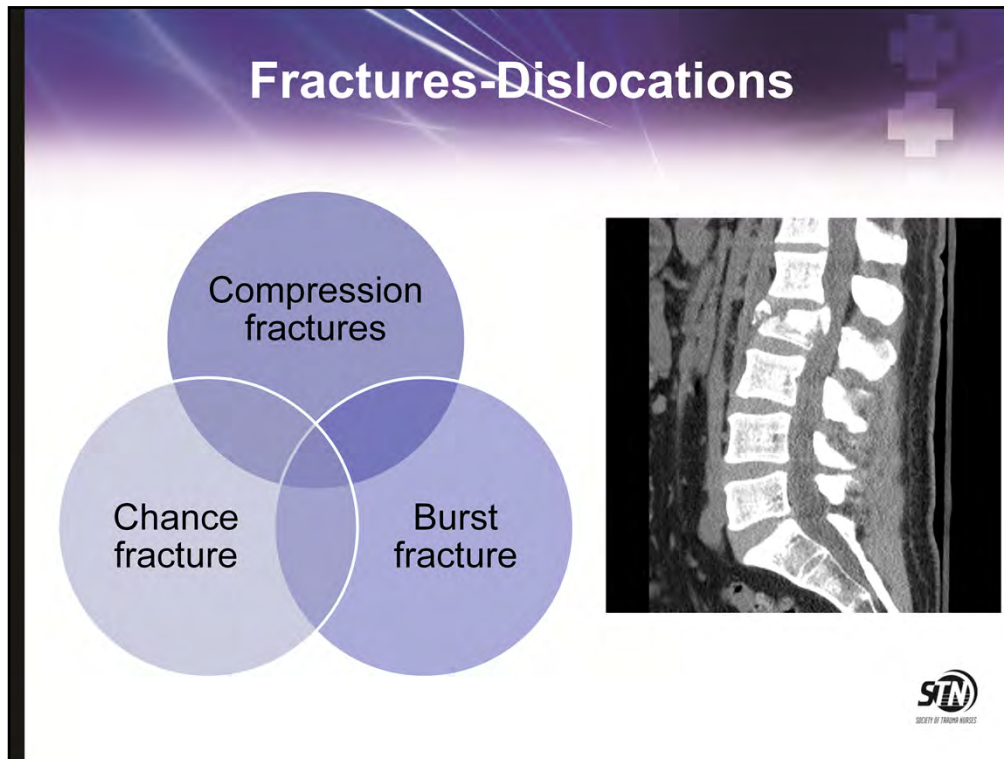
Type II (body)

Type III (involves vertebral body)

Rarely cord injury

**Image is a fractured odontoid (dens)**





#### Compression fx's

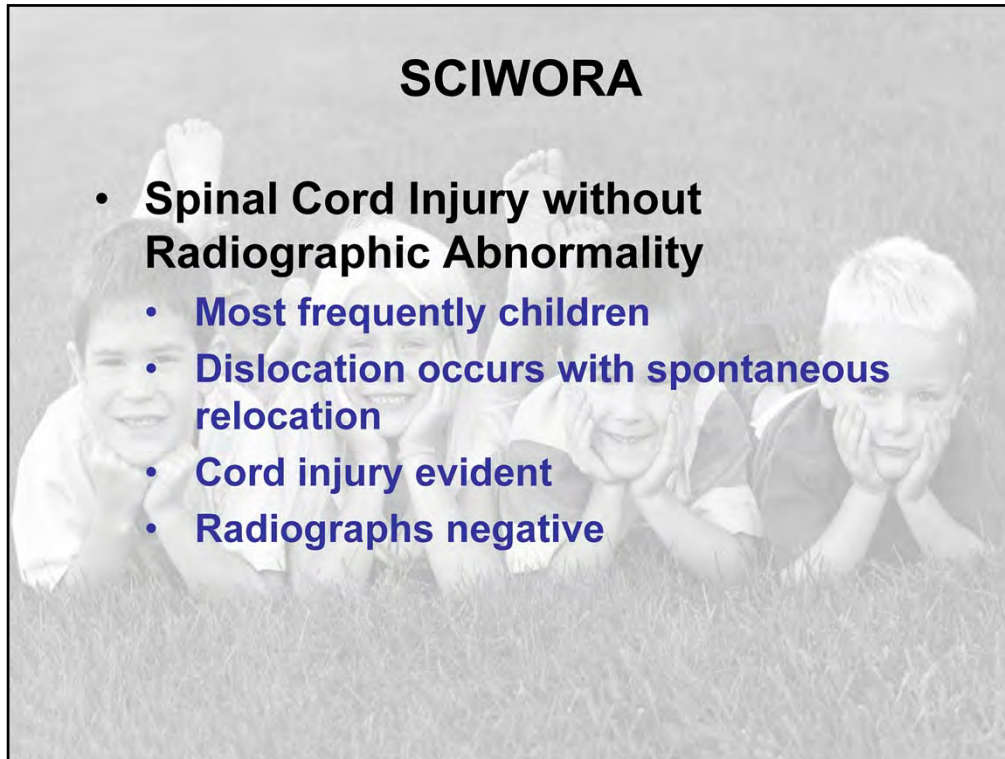
- Loss of height from axial load
- Vertebral body loss of height
- Thoracic and lumbar spine
- Degree of compression affects stability

#### Burst fx's

- Fracturing in an outward pattern that can impinge on the cord
- May have some compression
- Elements of spinal cord compression

#### Chance fx



- Usually L1-2, involves teardrop fx off anterior superior lip of the vertebral body
- May result in paraplegia and small bowel injury related to lap belt compression of the lumbar spine



- Injury can be contusion or transection of the spinal cord
- Frequently in children due to the flexibility of the spine and the heaviness of the head
- Injury evident yet no fracture or dislocation on x-ray

## 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





As with all trauma patients care begins with the ABC and remains as such

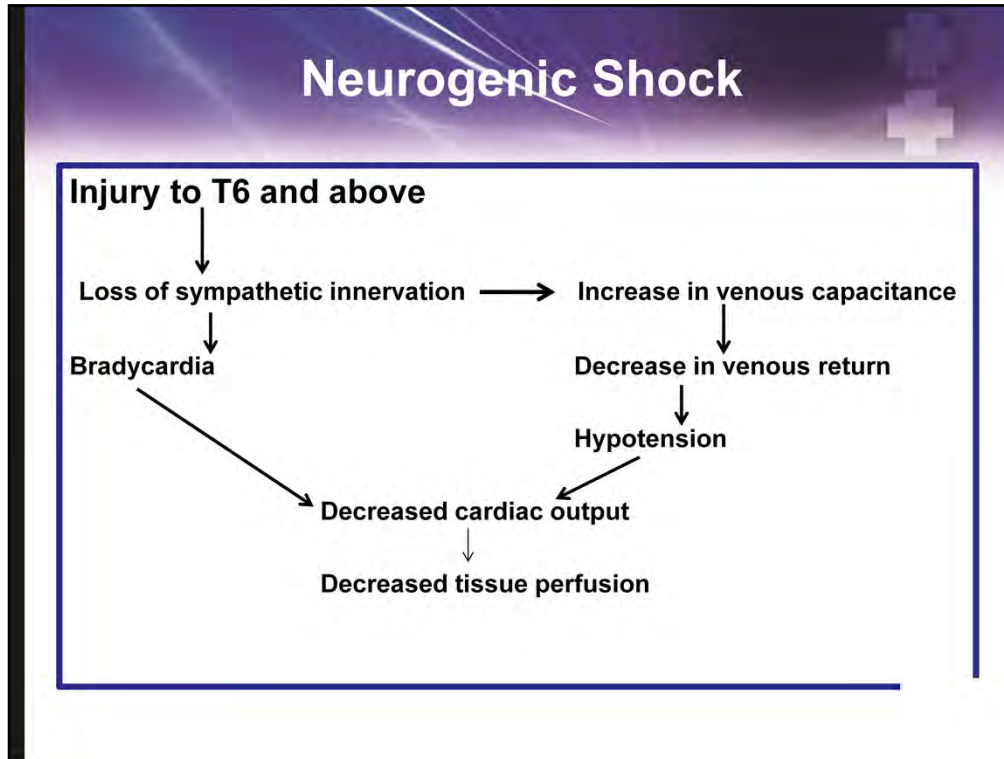
- Airway is always the priority
- If intubation is required, nasal intubation is often performed to avoid neck extension or use the glidescope visualization of the cords for intubation
  - Nasal intubation is a “blind” procedure and can cause bleeding or can intubate the skull through a basilar skull (cribriform plate) fracture
    - This can lead to further obstruction of the airway and aspiration of blood
  - Oral intubation can be performed with manual in-line traction and jaw thrust
  - MAINTAIN cervical alignment/protection
- Tidal volumes can be evaluated with incentive spirometry
  - Volumes of less than 1000 mL are indicative of probable impending failure
  - Watch for use of accessory muscles and the development of paradoxical breathing 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



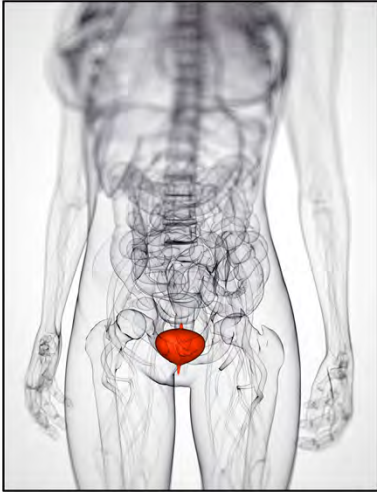
- Initially, systolic blood pressures of 90 mmHg will be adequate for transport, however, may not be adequate to reperfuse areas of injury or prevent systemic shock (as defined by a loss of end-organ perfusion)
- Bradycardia also results, vagus exits above C1, it will have uninterrupted and unopposed outflow
- At risk for vasovagal events with coughing, suctioning, or rapid position changes
- Treat only if patient becomes symptomatic
- Patient is a poikilothermic - will become the same temperature as the environment
  - Cannot constrict vessels or contract muscles to preserve heat (cannot shiver)
  - Keep patient covered and maintain continuous temperature monitoring
  - Hypothermia will adversely impact already bradycardic patient



- Sudden loss of sympathetic outflow and tone renders profound hypotension as the patient can no longer vasoconstrict below the injury to shunt blood and preserve blood pressure (loss of sympathetic control)

## Management

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



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- Maintain urine output – prevent hypotension
- Unable to control bladder
  - If sacral reflexes return, bladder control may as well
- Bowel and bladder routine will be necessary for spinal cord injured patients




## 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**




- Usually occurs at or near the time of injury
- Degree of severity usually related to level of injury
- Can last days to weeks
- Return of reflexes and development of spasticity heralds resolution of spinal shock
- As spinal shock resolves, autonomic dysreflexia becomes an issue

## 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**



Do not negate pain just because of para- or quadriplegia

## 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



### Communication systems



- Blink board consists of pictures or letters of the alphabet placed in a grid with numbers along the top and side
  - Blinks number across, then number down to select letter and spell words
  - One blink for “yes” and two blinks for “no”
  - Blink across first, blink down second and locate letter

	1	2	3	4	5
1	A	B	C	D	E
2	F	G	H	I	J
3	K	L	M	N	O
4	P	Q	R	S	T
5	U	V	W	X	Y

- Clicking is the sound made by one side of the tongue being rapidly sucked off the roof of the mouth
- Call bells can be adapted with build-ups being placed to enable use
  - Specialized call bells which require a light touch or sip/puff technique can also be employed

# Management

- **Special Treatment**
  - **Hypothermia**
    - Recommends 33°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



### Hypothermia

- Controversial at best

### Methylprednisolone

- No longer 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*



- Other pharmacological agents have been evaluated, however, study flaws have diluted the significance of the findings
- Further studies with adequate patient numbers, standardized medical and surgical protocols, control groups, and uniform relevant outcome measures are required before any of these become standard of care
- In 2011- still no demonstrated benefits to these therapies.
- Lazaroid compounds are potent inhibitors of lipid peroxidation, and their inability to influence other key injury processes, particularly during the late stages of cell injury, might partly explain the limited clinical efficacy
- An **excitatory amino acid antagonist (EAA)** is a pharmacological agent which acts to decrease the stimulation of receptors for excitatory amino acids (primarily [glutamate](#)).

## Management

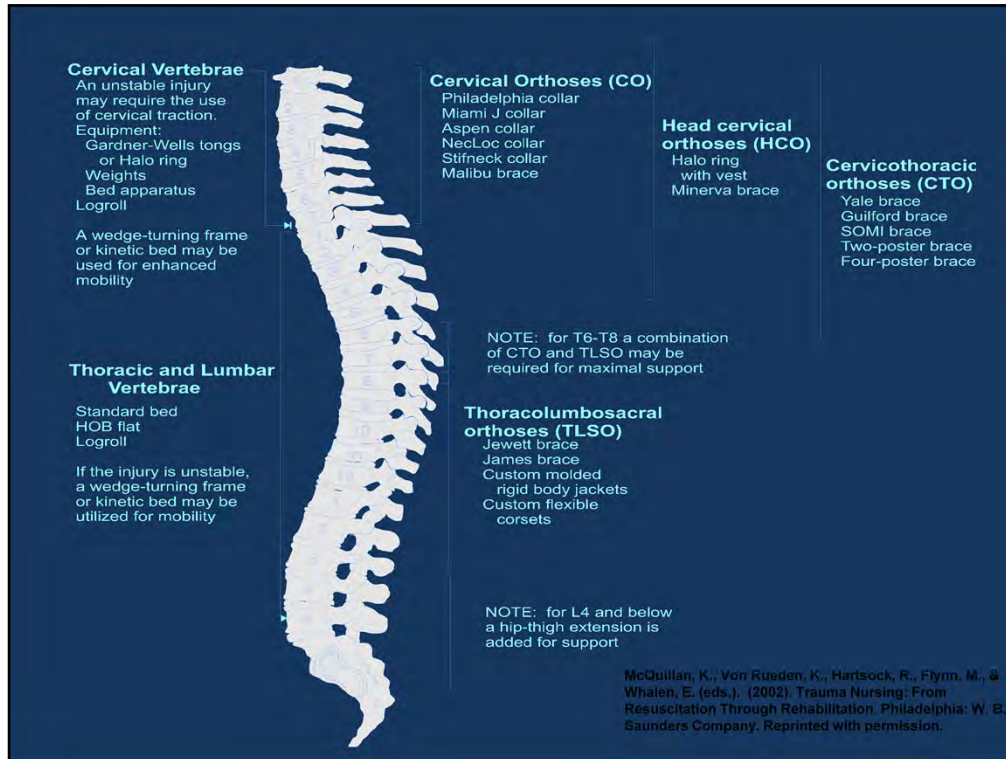
- **Reduction**
  - Cervical traction
    - Halo
    - Gardner-Wells tongs
  - Surgical
- **Stabilization**
  - Cervical collar – convert to padded collar as soon as possible
  - CTO or TLSO for low cervical, thoracic, lumbar injuries



- Extrication collar is the frontline intervention only
  - Extrication collars upgraded to other brands of hard collars with better padding to prevent skin breakdown over time
- Depending upon the stability of the injury, additional interventions may be required
- Cervical traction is employed to reduce or realign the spinal column in an effort to release an impingement on the spinal cord
  - Restoring blood flow- decreasing ischemia
  - Releasing direct pressure and enhancing stability
- Halo vest may also be employed to prevent additional movement of the cervical spine while healing
- Cervico-thoracic orthotic (CTO) for low cervical and high thoracic injuries
- Thoraco- lumbar-sacral orthotic (TLSO) for thoracic and lumbar fractures may be employed to provide stability as well as comfort
- These adjuncts may be used in addition to or in place of surgery



## 7\_Spinal Column and Spinal Cord Injuries



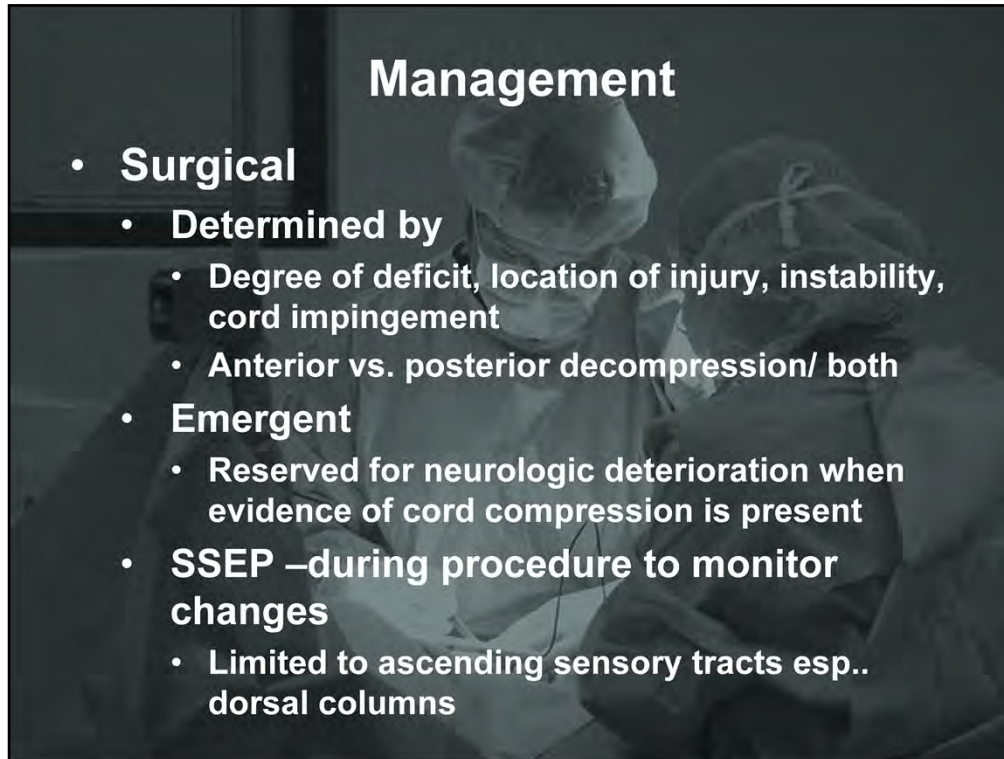
Management techniques for various levels cord and spinal column injuries

## Management

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





- Specialized beds such as the wedge turning frame (Stryker) or the kinetic therapy bed may be employed with or without traction to maintain spinal alignment and improve patient mobility and prevent respiratory complications



- Timing controversial regarding early (within 72 hrs) or after 7 days for “resting” the cord
- Anterior, posterior, or both decompression is dependent upon stability (ligaments that are injured)
- Anterior thoracic stabilization requires addition of a thoracic surgeon to access the spine
- Anterior lumbar stabilization requires addition of a general surgeon to access the lumbar spine
- Somatosensory evoked potentials (SSEP) are intra-operative studies performed to assess and monitor the integrity of the somatosensory pathway from a peripheral site to the cerebral cortex
  - Usual peripheral lead placement is ulnar and posterior tibial and scalp leads to monitor cortical and subcortical responses
  - Limitations are that an injury could occur to anterior segments of the cord and go undetected during surgery

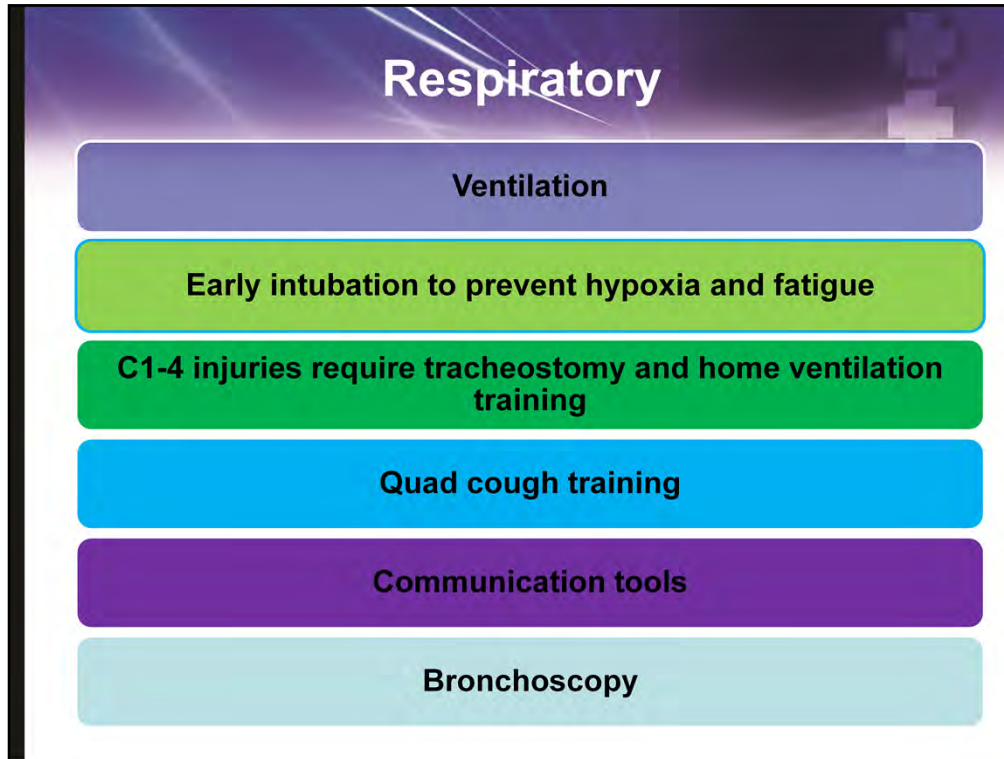
## Complication Prevention

- **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



- Depending on level of injury cervical and thoracic spine may affect innervation of the diaphragm (C3-4), the internal and external intercostals (T1-11), and the abdominal muscles (T7-12)
- Normal respiration, inspiration is active
- Diaphragm descends as the external intercostals lift the chest wall up and outward
- Expiration is passive unless a defensive maneuver is required
  - Forced expiration for a cough or sneeze requires the abdominal muscles to contract driving the diaphragm upwards, the internal intercostals drop the chest wall down, and air is forced out
- Alteration in respiratory dynamics with spinal cord injury changes ventilatory volume, increased work of breathing, and difficulties in lung protection
- Frequently unable to be sat upright or turned until definitive surgical intervention is performed
- Immobility itself lends toward multiple complications of the respiratory system – atelectasis, pneumonia, PE
- ABC's
- SCI patients may develop increasing fatigue as time passes
  - Little functional reserve, they will rapidly deteriorate once they exhaust themselves
  - Paraspinal edema may slowly narrow an airway
  - Closely monitor airway patency and respiratory mechanics

Paradoxical chest and abdominal movements may occur  
The chest drops as the abdomen rises on inspiration





- **Vital capacities of less than 800 ml generally will require mechanical ventilation**
- Monitor the patient's ability to hold the volume at peak inspiration
- Secretion clearance, a cough technique called "quad" coughing should be employed
  - Quad coughing is performed by placing the heels of the hands on the patient's abdomen and pushing inward rapidly as the patient exhales forcibly
  - There is question of avoiding the quad cough in patients with an inferior vena cava filter
- For patients requiring long term ventilator support, tracheostomies are usually performed
  - Aids in the process and also allows for improved communication and in some patients, initiation of oral intake
- Bronchoscopy is sometimes employed for persistent areas of lung collapse, especially if percussion or mobilization have failed to open or clear airways



## Respiratory

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





- Ventilated patients – monitor weaning parameters and the usual respiratory tests
- Assist with lung clearance through suctioning, postural drainage (or rotational bed therapy), chest PT
  - Dependent upon stability of spine to perform postural drainage



## Respiratory

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



- Serial pulmonary function tests can provide information about the strength of the respiratory muscles
- Incentive spirometry provides a measurable means of monitoring volumes
- Some SCI patients respond to noninvasive positive pressure ventilation
  - Assists with the recruitment of collapsed alveoli by assisting with maintaining functional capacity, reduces the work of breathing and improves saturation
- For spontaneous breathers who can be upright 30 degrees or more, an abdominal binder is applied below the costal margin to the level of the iliac crests to compress the abdominal contents upward
  - Aids breathing by bringing the diaphragm into a better resting position
- Patients should be mobilized as soon as possible
  - Bedrest, logrolling or turning beds such as the wedge turning bed or a kinetic therapy bed should be employed
  - Once cleared for the upright position, patients should be lifted into appropriate chairs

## Complication Prevention


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



- Neurogenic shock (hypotension and bradycardia) can last days to several weeks/months
- While blood pools in the lower extremities without the benefit of sympathetic control to vasoconstrict, blood pressure drops
- In the same way, bradycardia occurs
- Invasive monitoring – guides fluid therapy
- Assure that there is NO source of bleeding; initiate fluid resuscitation and supplement with vasopressors once hemodynamic shock has been ruled out
- Bradycardia is usually asymptomatic and should only be treated if it becomes 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



- Along with bradycardia, patients are prone to “vasovagal” events
- Coughing, suctioning, sudden position changes, or any other maneuver that stimulates the vagus can induce cardiac arrest
- Hyperoxygenation on 100% oxygen prior to suctioning or turning may help reduce the incidence
- Atropine 0.5 to 1 mg IV bolus should be kept at hand in the event of cardiac standstill
- Medications such as oral albuterol, theophylline, and pseudoephedrine have been employed in efforts to raise baseline heart rates
- If this becomes problematic, temporary or permanent pacemakers can be utilized as needed
- Compression of lower extremities and mesentery may aid venous return
- Should simple measures fail, the addition of salt tablets or Florinef, a mineralocorticoid, to promote salt and water retention may be helpful
- Sympathomimetics such as pseudoephedrine or midodrine may also be beneficial

## Cardiovascular


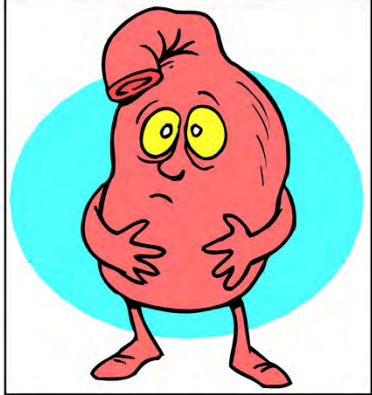
- **Poikilothermia**
  - Inability to shiver/sweat and adjust body temperature
  - Keep patient warm
  - Warm the environment
  - Monitor skin to prevent burns or frostbite from exposure
    - Insensate skin



- The loss of the ability to shiver and retain heat or sweating to release heat produces the condition known as poikilothermia
- Closely monitor for temperature extremes
- Low core temperatures should be warmed gently via blankets, forced warmed air blankets, or if mechanically ventilated warmed active humidification circuits
  - Maintenance of core temperature may also assist with heart rate management
- Hyperthermic patients, gentle cooling methods can be used
- Extreme care must be utilized to prevent burning or “frostbite” of patients since they are often insensate to areas where heating or cooling blankets come into contact with their skin
  - Skin monitoring and position changes must be performed

## Complication Prevention

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




- GI complication prevention is essential and similar to all critical patients
- Cholecystitis due to abnormal gall bladder motility, altered intestinal motility, abnormal enterohepatic circulation
  - Symptoms
    - Referred shoulder tip pain, anorexia, nausea and vomiting, increased spasticity, autonomic dysreflexia
  - Treatment
    - Surgery
  - Important to remember that many of the classic signs of gall bladder disease such as a rigid abdomen, tenderness and peritoneal rebound may be absent in midthoracic and higher injuries and may delay diagnosis and treatment



## Gastrointestinal

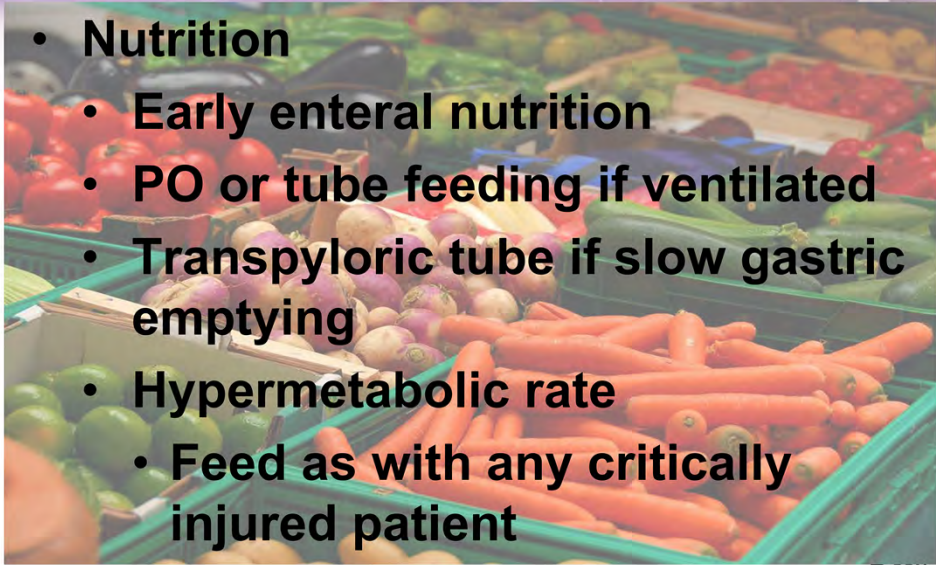
- Abdominal distention
  - Nasogastric tube to decompress stomach
  - Monitor bowel sounds
  - Monitor N/G output for bleeding
  - Gastric prophylaxis-
    - Histamine blockers, proton-pump inhibitors, antacids
- Bowel routine
  - Stool softeners, suppositories; high fiber diet
  - Digital stimulation,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



- Most patients will develop an adynamic ileus at all levels of the spine and can occur with fracture only
- Abdominal distention can further impair breathing, especially for patients who rely upon the diaphragm for the work of breathing
- Stress ulcer formation risk is the same as for all critically injured patients
- Bowel function is also a priority to prevent further abdominal distention and respiratory impingement – initiate early bowel routine to prevent constipation
- Constipation is a life-long consequence of spinal cord injury
  - High level injuries maintain reflexive defecation, but an inability to sense urge
  - Sacral segment injuries destroy the sacral innervation and reflex center
  - Fecal retention and oozing are experienced
  - Avoid harsh laxatives which produce unpredictable timing of defecation and may produce diarrhea



## 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**

SOCIETY OF TRAUMA NURSES

- Nutrition plays a vital role in healing
  - Gastric/enteral feeding helps maintain intestinal integrity
  - Assists with ulcer prophylaxis and decreases the risk of bacterial translocation
  - If the patient has issues with gastric emptying, efforts should be made to place a transpyloric tube to aid early initiation of enteral feeds

## 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





- DVT prophylaxis is an area in which a definitive standard of care exists
- The Consortium for Spinal Cord Medicine has created clinical practice guidelines for the prevention of thromboembolism in spinal cord injury. The American Association of Neurological Surgeons/Congress of Neurological Surgeons Joint Section on Disorders of the Spine and Peripheral Nerves have also published standards of care for this management \*
  - Implement prophylaxis
  - Use of low molecular weight heparin, rotating beds, adjusted dose heparin, or a combination of modalities is recommended
  - Low-dose heparin in conjunction with pneumatic compression stocking or electrical stimulation is recommended
  - Heparin or oral anti-coagulation alone is not recommended
  - Recommended duration of treatment is three months (approx. the time required from injury through rehab to return to home)

\*The American Association of Neurological Surgeons/Congress of Neurological Surgeons Joint Section on Disorders of the Spine and Peripheral Nerves, *Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injury*, 2002

## Complication Prevention

### Reflexive bladder – involuntary contraction

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




Bladder management is multi-factorial

- Consideration is given to age, gender, functional level, body habitus, motivation, and lifestyle
- Reflexive, or neurogenic, bladder has an intact reflex arch
  - From the sacral plexus
  - Involuntary contraction of the bladder causes voiding
- Transitioned to straight catheterization once urinary output decreases to less than or equal to 2.5 liters per day (approx 500-600 ml q4-6hr)
- Fluid restriction is implemented
- Encouraged to drink the full limit daily to maintain bladder flushing
- For males, once reflexive voids occur, post void residuals must be evaluated by straight catheterization
  - External devices may be employed, however, they must be changed daily to prevent infection and skin breakdown
- Females –suprapubic tube

## 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)



- **Areflexive, or atonic**, bladder is usually seen in patients with injuries to the conus medullaris
- Bladder and sphincter are denervated leading to urinary retention with overflow voiding
- Valsalva maneuver, bearing down, or Crede maneuver (manual compression of the bladder with the heel of the hand), may assist bladder emptying
- Skin integrity is a major issue
- Surgical options include continent urinary conduits



### **DSD-- Loss of coordination between the bladder and the external sphincter**

- Bladder and the external sphincter both contract in response to fullness
- Bladder contracts to release urine, the external sphincter contracts instead of relaxing to allow urine passage leading to elevated voiding pressures
- Can cause vesicoureteral reflux and hydronephrosis
- Pharmacological treatment
  - Lower bladder outlet resistance Alpha-1 adrenergic blockers (prazosin, terazosin)
  - Reduce external sphincter spasticity Anti-spasmodics (dantrolene, baclofen)
  - Relax detrusor muscle and lower bladder pressure Anti-cholinergics (propanthelene bromide, oxybutinin)



## 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 tract infection - Most common complication for SCI patient in the first year post-injury**
- Removal of indwelling catheter reduces risk
- Positive UA in the presence of other clinical symptoms is the key point for diagnosis
- Education is a priority for patients and their families
- Repetitive infections and potential for ascension to the kidney is a great risk
  - Can lead to renal failure
- Cranberry juice/tablets increase urine acidity and decrease incidence of infection

## 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



- Occurs in a low percentage of spinal cord patients



## 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



- Implications for skin integrity start at the time of injury for the spinal cord injured patient
- Hypotension and hypoxia coupled with the sensorimotor loss places the patient at high risk for breakdown
- Precipitating factors include
  - Immobility, loss of sensation, incontinence of stool and urine, and poor nutrition
- It is important to recognize that skin breakdown can delay surgery, prolong immobilization, increase hospital stay, increase risk of infection, precipitate Autonomic Dysreflexia (AD), and delay rehabilitation
- The single most important treatment for skin breakdown is prevention
- A simple decubitus can result in sepsis and death, increased hospital LOS and bill
- Pressure release maneuvers include the use of specialty cushions, tilting of wheelchair back for 5 minutes, lifting the hip or shifting patient side-to-side or performing pushups on the arms of the wheelchair every twenty minutes
- High level patients often utilize chairs which automatically shift weight or inflate/deflate small seat cushion air bladders to release pressure especially on the ischium
- Specialists such as enterostomal therapists can assist in the development of a wound care program
- Wound has significant depth surgical intervention may be required

## 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)



- Many theories surrounding the development of spasticity
  - Occurs in patients who have sustained injuries above the conus
- There is a loss of inhibitory influences upon motor neurons and a subsequent heightened sensitivity to surrounding excitatory influences
- Distinctive patterns of muscle pattern often occur
- Occur in isolation or combination
- Spasticity can have positive and negative effects
  - Evaluate by assessing resistance to passive ROM to an affected extremity
  - Modified Ashworth Scale which assigns a numeric value from 0 for no increase in tone to 4 for rigid tone, is one tool to quantify spasticity
  - The most important evaluation of spasticity is the patient's perception of its impact upon quality of life
- Pharmacological interventions include
  - Baclofen and benzodiazepines
  - Clonidine and tizanidine in conjunction with baclofen
  - Gabapentin
  - Regional Botox injection
  - Intrathecal pump of anti-spasmodics
- Surgical intervention requires the severing of neural elements to prevent spasms
  - Once severed, there is no ability to restore function should neural regeneration become possible in the future
  - This should be utilized in extreme cases only

## Musculoskeletal

### Heterotrophic ossification

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





- Most common site is the hips
- Monitor shoulder, elbow, hip, and knee joints closely
- **PREVENTION –aggressive ROM, mobilization, NSAIDS, didronel, surgery**
- Didronel cannot be administered if the patient has an active, healing fracture
  - It will prevent ossification of the injury
- Surgical intervention is delayed often for up to one year to permit maturation of the ectopic bone

## 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



- Stronger muscles override weaker ones leading to a shortening of the stronger muscle
- Can occur within one week of injury
- Early initiation of PT and OT
- Education of family to assist with ROM and positioning involves them in care while aiding the patient
- Caution must be utilized to avoid forcing a contracted joint to prevent tissue injury or bone fracture

## Complication Prevention



### Neurologic - Post traumatic Syngomyelia

A fluid filled cavity which develops within the spinal cord

Most common symptom is pain

Surgical decompression

Serial monitoring via MRI



- Syringomyelia is a late complication
- Fluid-filled cavity within the spinal cord resulting from a loss of spinal cord substance that can occur months to decades after initial injury
- Most common symptom is usually pain. Other symptoms are:
  - loss of DTRs
  - ascending sensory or motor level
  - increasing autonomic signs
- Definitive diagnosis is made with MRI and clinical exam
- Management of PTS is controversial
  - Surgical decompression
    - Primary drainage
    - Laminectomy with subarachnoid space reconstruction
    - Shunting
  - Goal of surgery is to reduce pain and prevent further neurological deterioration
  - Success rates are unreliable for surgery



## Complication Prevention

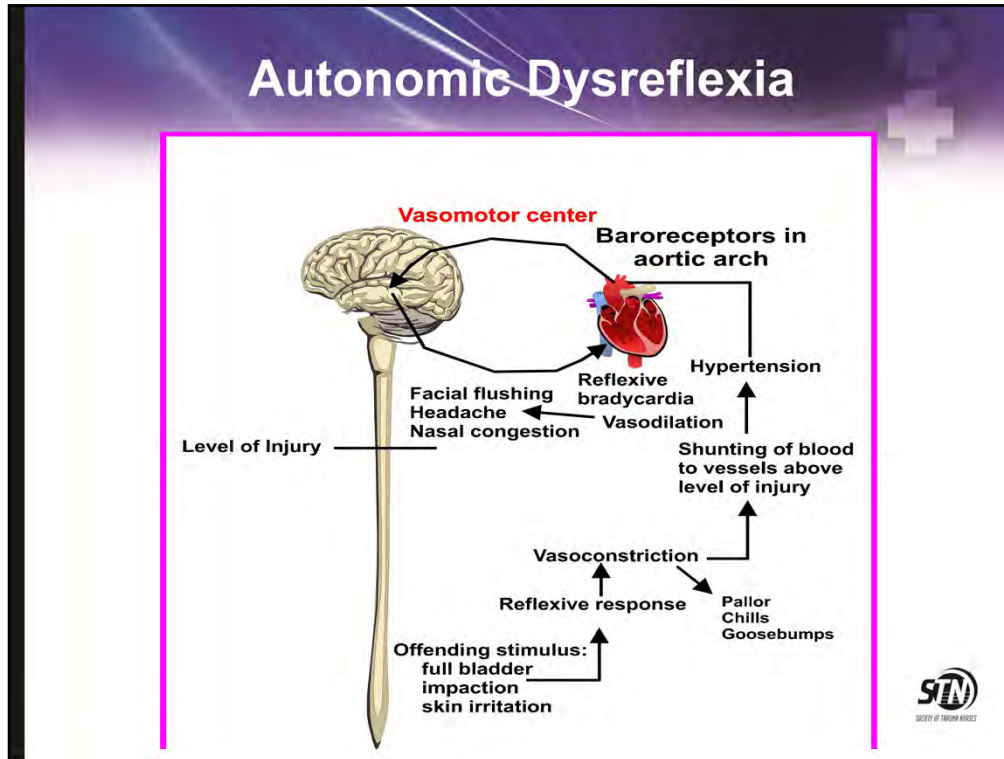
### Autonomic dysreflexia

- 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



- Once spinal shock has resolved, patients with injuries at T6 and above are at risk for the development of autonomic dysreflexia
- AD is the massive, uncontrolled sympathetic reflex response to a noxious stimulus, below the level of the lesion





### Pathophysiology

- Offending stimuli irritates the sympathetic nervous system below the level of the lesion
- Initiates a sympathetic reflex response producing a massive vasoconstriction
- Blood is shunted to the larger uncontracted vessels above the level of injury causing hypertension
- Increased venous return coupled with the rising blood pressure stimulate the baroreceptors in the carotid arteries and aortic arch
- Receptors respond by sending a message to the vasomotor center in the brain
- Messages to the heart, causing reflexive slowing, and to the blood vessels causing vasodilation
- Since the messages cannot be transmitted below the level of the injury, vasodilation occurs only above the level of the lesion

**Produces the characteristic signs and symptoms which appear to contradict each other above and below the level of injury**

### Above the lesion

- Flushing
- Nasal congestion
- Headache

### Below the lesion

- Pallor
- Chills
- Goosebumps

## 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



- **This is a potentially life threatening event**
- **If left untreated, it could precipitate myocardial infarction, subarachnoid hemorrhage or stroke**
- Can be easily overlooked since many patients are chronically bradycardic
- Observe for bradycardia **with hypertension**
- What appears to be a “normal” blood pressure may be an earlier indicator since these patients frequently have lower blood pressure from the loss of sympathetic innervation
  
- Interventions should be aimed at prevention and/or early recognition of signs and symptoms
- Attempt to identify the offending stimuli and intervene
  - Palpate and catheterize bladder if distended
  - Perform digital exam for impaction **using an anesthetic ointment** to prevent exacerbation of syndrome
  - If abdominal distention is present in the absence of impaction consider a laxative
  - Remove splints and loosen clothing
- If these measures fail to resolve the problem, hypertensive management, such as the administration of hydralazine hydrochloride or diazoxide should be initiated
- For recurrent AD, the use of alpha-adrenergic blockers such as terazosin, have been effective
- Patients and families must be educated about the symptoms and treatment of AD

## 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





- Chronic pain and depression are like the chicken and the egg debate, “what comes first?”
- Is the patient depressed because he is in pain or is the pain because he is depressed?
- Studies show between 40-46% of patients experience chronic pain issues which impact the quality of their lives
- Pain can be classified as nociceptive or neurogenic
  - Neurogenic pain can be more difficult to manage
- Higher level injuries have a loss of sensory balance
- “gating” theory, there is little competition to block the pain impulse from being perceived
- Shoulder joints are frequently involved
  - Exacerbated by the chronic overuse of the joint for ADLs and chair locomotion
  - Direct impact upon the quality of day to day life
- Depression can be a facilitating factor
  - Pain can reduce the ability to cope with severe distress and impairment which worsens depression
- The Consortium for Spinal Cord Medicine has developed guidelines to aid practitioners in screening and treating depression and chronic pain

## 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





- Sexual rehabilitation is the same as for all areas, to assess level of function and maximize outcome
  - Erection = parasympathetic (point); Ejaculation = sympathetic (shoot)
  - If the sacral reflexes are intact, the patient will have a reflexive erection
  - Short duration
  - Ejaculation and fertility are usually considered together
- Technical aides include O rings and vacuum pumps
- Pharmacological agents include intracavernous injections
- Penile prosthesis can be utilized for reflexive or areflexive men
- Ejaculation aides must be used cautiously to prevent initiation of Autonomic Dysreflexia

## 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



- Fertility generally unaffected
- Pregnancy should be closely monitored to prevent complications
- A few considerations
  - Diaphragmatic displacement can further impair respiration
  - Constipation is a frequent side effect of prenatal vitamins
  - Could induce Autonomic Dysreflexia
  - Changes in blood volume and blood pressure
  - Alteration in urinary management



## Rehabilitation



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



- Begins at admission with prevention of secondary injury and initiation of early therapies
- Includes 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

