SPINAL INJURY
Spinal Injuries

Topics To Be Discussed:
- Morbidity and Mortality
- Anatomy of the Spine and Spinal Cord
- General Assessment
- Spinal Cord Injuries
- Management
Incidence of SCI

- 10,000 - 20,000 spinal cord injuries per year in the US.
- Incidence:
  - ~ 82% occur in men.
  - ~ 61% occur in ages 16 – 30.
- Common causes:
  - MVC (48%).
  - Falls (21%).
  - Penetrating injuries (15%).
  - Sports injuries (14%).
There seems to be lots of job security...
Morbidity & Mortality

- 40% of trauma patients with neurologic deficits will have temporary or permanent spinal cord injury (SCI).
- There are many more vertebral injuries that do not result in cord injury.
- Most commonly injured vertebrae:
  2. C1-C2.
Prevention

- Primary Injury Prevention:
  - Public Education.
  - EMS Community Service Projects.

- Secondary Injury Prevention:
  - Education in proper patient handling and movement can decrease secondary SCI. This includes:
    » First Responder Care.
    » EMS Care.
    » Tertiary Hospital Care.
Anatomy of the Spine and Spinal Cord
Anatomy Review

- 33 vertebrae.
- Spine supported by pelvis.
- Key ligaments and muscles connect head to pelvis.
  - Anterior longitudinal ligament:
    » anterior portion of the vertebral body.
    » major source of stability.
    » protects against hyperextension.
  - Posterior longitudinal ligament:
    » posterior vertebral body within the vertebral canal.
    » protects against hyperflexion.
Ligamentum Flavum

Facet Capsular Ligament

Interspinous Ligament

Supraspinous Ligament

Intertransverse Ligament

Posterior Longitudinal Ligament

Anterior Longitudinal Ligament
Anatomy Review

- **Cervical Spine**
  - 7 vertebrae.
  - Very flexible.
  - C1, also known as the atlas.
  - C2, also known as the axis.

- **Thoracic Spine**
  - 12 vertebrae.
  - Ribs connected to spine.
  - Provides rigid framework for the thorax.
Anatomy Review

- **Lumbar Spine**
  - 5 vertebrae.
  - Largest vertebral bodies.
  - Carries most of the body’s weight.

- **Sacrum**
  - 5 fused vertebrae.
  - Common to spine and pelvis.

- **Coccyx**
  - 4 fused vertebrae.
  - “Tailbone.”
Anatomy of the Vertebra

- Atlas (the first cervical vertebra)
- Axis (the second cervical vertebra)
- Spinous Process
- Transverse process
- Vertebral body

C1
C2
C3
C4
C5
C6
C7
T1
**Anatomy Review**

**Vertebral body**
- Posterior portion forms part of vertebral foramen.
- Increases in size from cervical to sacral.
- Spinous process.
- Transverse process.

**Vertebral foramen**
- Opening for spinal cord.

**Intervertebral disk**
- Shock absorber (fibrocartilage).
Anatomy Review

- Blood supplied by vertebral and spinal arteries.
- Gray matter is made up of unmyelinated nerve fibers in the core of the cord.
- White matter is made up of longitudinal bundles of myelinated nerve fibers.
Spinal cord ends at ~ L-2. Nerves to lower extremities continue as the cauda equina.
1. Gracile tubercle
2. Cuneate tubercle
3. Posterior median sulcus
4. Posterior intermediate sulcus
5. Vertebral artery
   1st cervical spinal ganglion
6. Motor root of first cervical nerve
7. Cut surface of posterior arch of atlas
Anatomy Review

- Spinal Cord
  - Thoracic and lumbar levels supply sympathetic nervous system fibers.
  - Cervical and sacral levels supply parasympathetic nervous system fibers.
Cervical region of the spinal cord includes respiratory and cardiac centers as well as nerve roots for Cranial Nerves IX (Glossopharyngeal) and X (Vagus).
Phrenic Nerve

- Originates in the neck from C3, C4, and C5 roots.
- The right phrenic nerve passes through the diaphragm close to the inferior vena cava.
- The left branch has sensory fibers to the diaphragmatic pleura peritoneum and motor fibers to the diaphragm.
- The only motor supply to the diaphragm.
Spinal Cord Pathways

- Ascending Nerve Tracts (sensory input):
  - Carry impulses from body structures and sensory information to the brain.
  - Posterior column (dorsal):
    » Conveys nerve impulses for proprioception, discriminative touch, pressure, vibration, and two-point discrimination.
    » Cross over at the medulla from one side to the other.
    ✷ e.g. impulses from left side of body ascend to the right side of the brain.
Spinal Cord Pathways

Spinothalamic Tracts (anterolateral)

» Convey nerve impulse for sensing pain, temperature, and light touch.

» Impulses cross over in the spinal cord not the brain.

» Lateral tracts:
  ♦ Conduct impulses of pain and temperature to the brain.

» Anterior tracts:
  ♦ Carry impulses of light touch and pressure.
Spinal Cord Pathways

- Descending Motor Tracts (motor output):
  - Conveys motor impulses from brain to the body.
  - Includes the pyramidal tracts, Corticospinal and Corticobulbar.
    » Corticospinal tracts:
      - destined to cause precise voluntary movement and skeletal muscle activity
      - lateral tract crosses over at the level of the medulla.
Spinal Cord Pathways

- **Descending Motor Tracts (motor output)**
  - Extrapyramidal tracts:
    - Pontine reticular and lateral vestibular have powerful excitatory effects on extensor muscles.
    - Brain stem lesions above these two areas but below the midbrain cause dramatic increase in extensor tone called decerebrate rigidity or posturing.

- Reticulospinal impulses control muscle tone and sweat gland activity.
- Rubrospinal impulses control muscle coordination and control of posture.
Example of Motor and Sensory Pathways

Spinothalamic tract

To thalamus and cerebral cortex (sensory)

Brain Stem

Spinal Cord

Pain - Temp

Proprioception (conscious)

Posterior column

Motor Cortex

Corticospinal tract

Example Motor Pathway (corticospinal tract)
Reflex Arc
Reflex Arc

- A sensory neuron carries a stimulus to the spinal cord.
- It connects or synapses with a motor neuron that carries the reflex back to an appropriate muscle or gland.
31 pairs originate from the spinal cord.

- Carry impulses for both sensation and motor function.
- Named according to level of spine from where they arise:
  - Cervical 1-8.
  - Thoracic 1-12.
  - Lumbar 1-5.
  - Sacral 1-5.
  - Coccygeal 1.
Dermatomes

- **Dermatome:**
  - Specific area in which the spinal nerve travels or controls.
  - Useful in assessment of specific level SCI.

- **Plexus:**
  - Peripheral nerves rejoin and function as a group.
  - Cervical Plexus controls the diaphragm and neck.
Dermatomes

- C3, 4
  - motor: shoulder shrug
  - sensory: top of shoulder

- C3, 4, 5
  - motor: diaphragm
  - sensory: top of shoulder

- C5, 6
  - motor: elbow flexion
  - sensory: thumb

- C7
  - motor: elbow, wrist, finger extension
  - sensory: middle finger

- C8, T1
  - motor: finger abduction and adduction
  - sensory: little finger

- T4
  - motor: level of nipple

- T10
  - motor: level of umbilicus
Dermatomes

- **L1, 2**
  - motor: hip flexion
  - sensory: inguinal crease
- **L3,4**
  - motor: quadriceps
  - sensory: medial thigh, calf
- **L5**
  - motor: great toe, foot dorsiflexion
  - sensory: lateral calf
- **S1**
  - motor: knee flexion
  - sensory: lateral foot
- **S1, 2**
  - motor: foot plantar flexion
- **S2,3,4**
  - motor: anal sphincter tone
  - sensory: perianal
SCI Overview
Kinematics of Blunt Spinal Injury

- Hyperextension
- Hyperflexion
- Compression
- Rotation
- Lateral Stress
- Distraction
Hyperextension

Sprain or strain of cervical tissues

Hyperflexion
SCI General Assessment

- ABCs
  - Airway and/or breathing impairment
    » Inability to maintain airway.
    » Apnea.
    » Diaphragmatic breathing:
      - High cervical spine injury where the phrenic nerve remains intact, but impulses to the intercostal muscles have been disrupted.
      - These patients need ventilatory assistance as they will fatigue until they are conditioned.
  - Cardiovascular impairment
    » Neurogenic shock.
    » Hypoperfusion.
SCI General Assessment

- Neurologic Status:
  - Level of Consciousness
    » If altered, think brain injury as well.
  - Cognition
    » Cooperative.
    » No impairment (drugs, alcohol).
    » Understands and recalls events surrounding injury.
    » No distracting injuries.
    » No difficulty in communication.
SCI General Assessment

- Assess Function and Sensation
  - Palpate over each spinous process
  - Motor function
    » Shrug shoulders
    » Spread fingers of both hands and keep apart with force
    » “Hitchhike” {T1}
    » Foot plantar flexors (gas pedal) {S1,2}
- Sensation (position and pain)
  » Weakness, numbness, paresthesia
  » Pain or pressure, sharp vs dull, symmetry
- Priapism
Spinal Cord Injuries

- Forces
  - Direct traumatic injury
    » Stab or gunshot directly to the spine
  - Excessive movement
    » Acceleration
    » Deceleration
    » Deformation
Spinal Cord Injuries

- Forces
  - Directional forces
    - Flexion, hyperflexion
    - Extension, hyperextension
    - Rotational
    - Lateral bending
    - Vertical compression
    - Distraction
Spinal Cord Injuries

- Primary cord injury:
  - Damage is immediate and irreversible.
  - Cord is cut, torn, crushed, or blood supply interrupted.

- Secondary cord injury develops later from:
  - Hypoxia, swelling, hypotension, compression from bleeding or swelling around the cord.
  - Good patient care can limit secondary injury.
Spinal Cord Injuries

- **Cord concussion and cord contusion**
  - Temporary loss of cord-mediated function.

- **Cord compression**
  - Decompression required to minimize permanent injury.

- **Laceration**
  - Permanent injury dependent on degree of damage.

- **Hemorrhage**
  - May result in local cord ischemia.
Spinal Cord Injuries

- **Cord transection:**
  - **Complete**
    - All tracts disrupted.
    - Cord mediated functions below transection are permanently lost.
  - Determined ~ 24 hours post injury.
  - Possible results:
    - Death due to non-survivable injury.
    - Quadriplegia.
    - Paraplegia.
Terminology

- **Paraplegia:**
  - Loss of motor and/or sensory function in thoracic, lumbar or sacral segments of SC (arm function is spared).

- **Quadriplegia:**
  - Loss of motor and/or sensory function in the cervical segments of SC and below.
Spinal Cord Injuries

- Cord transection:
  - Incomplete
    » Some tracts and cord mediated functions remain intact.
    » Potential for recovery of function.
    » Possible syndromes:
      - Brown-Sequard Syndrome.
      - Anterior Cord Syndrome.
      - Central Cord Syndrome.
Brown-Sequard Syndrome

- Incomplete Cord Injury:
  - Injury to one side of the cord (Hemisection).
  - Often due to penetrating injury or vertebral dislocation.
  - Complete damage to all spinal tracts on affected side.
  - Good prognosis for recovery.
Knife injury to cord.
Brown-Sequard Syndrome

- Exam Findings:
  - Ipsilateral loss of motor function motion, position, vibration, and light touch.
  - Contralateral loss of sensation to pain and temperature.
  - Bladder and bowel dysfunction (usually short term).
Anterior Cord Syndrome

- Anterior Spinal Artery Syndrome
  - Supplies the anterior 2/3 of the spinal cord in the upper thoracic region.
  - Caused by bony fragments or pressure on spinal arteries.
Anterior Cord Syndrome

Exam Findings:
- Variable loss of motor function and sensitivity to pinprick and temperature.
- Loss of motor function and sensation to pain, temperature, and light touch.
- Proprioception (position sense) and vibration are preserved.
Central Cord Syndrome

- Usually occurs with a hyperextension of the cervical region.

- Exam Findings:
  - Weakness or paresthesias in upper extremities. Normal strength in lower extremities.
  - Varying degree of bladder dysfunction.
Cauda Equina Syndrome

- Injury to nerves within the spinal cord as they exit the lumbar and sacral regions.
  - Usually occurs with fractures below L2.
  - Specific dysfunction depends on level of injury.

- Exam Findings:
  - Flaccid-type paralysis of lower body.
  - Bladder and bowel impairment.
Neurogenic Shock

- Temporary loss of autonomic function of the cord at the level of injury.
  - Usually results from cervical or high thoracic injury.
- Does not always involve permanent primary injury.
- Effects may be temporary and resolve in hours to weeks.
- Goal is to avoid secondary injury.
Neurogenic Shock

Presentation:

- Flaccid paralysis distal to injury site.
- Loss of autonomic function.
  » Hypotension or relative hypotension.
  » Vasodilation.
  » Loss of bladder and bowel control.
  » Priapism.
  » Loss of thermoregulation.
  » Warm, pink, dry skin below injury site.
  » Relative bradycardia.
  » May have sympathetic nervous system response presentation above the injury.
Autonomic Hyper-reflexia Syndrome

- Associated with SCI patients (usually T-6 or above) some time after initial injury.
  - Vasculature has adapted to loss of sympathetic tone.
  - Blood pressure normalized.
  - No vasodilation response to increased BP.
- Autonomic nervous system reflexively responds causing:
  - Increased BP.
  - Bradycardia.
  - Peripheral and visceral vessels unable to dilate.
Autonomic Hyper-reflexia Syndrome

- Presentation:
  - Paroxysmal hypertension, possibly extreme.
  - Headache.
  - Blurred vision.
  - Sweating and flushed skin above level of injury.
  - Increased nasal congestion.
  - Nausea.
  - Bradycardia.
  - Look for distended bladder or bowel. Commonly a cause or trigger for hyper-reflexia.
Non-Traumatic Conditions

- Low Back Pain (LBP):
  - 60-90% of population experience some form of LBP.
  - Very small number due to sciatica (lumbar nerve root).
  - Most causes cannot be specifically diagnosed.
  - Risk Factors:
    » Repetitious lifting or straining.
    » Chronic exposure to vibration (e.g. vehicle).
    » Osteoporosis.
    » Age.
Non-Traumatic Conditions

- Low Back Pain (LBP)
  - Causes:
    » Tumor
    » Prolapsed disk
    » Bursitis
    » Degenerative joint disease
    » Problems with spinal mobility
    » Inflammation caused by infection
    » Fractures
    » Ligament strains
Non-Traumatic Conditions

- **Low Back Pain (LBP)**
  - Degenerative disk disease:
    » Common over 50 years of age.
    » Narrowing of the disk.
    » Biochemical alterations of intervertebral disk.
  - Herniated intervertebral disk:
    » Tear in the posterior rim of capsule enclosing the gelatinous center of the disk.
    » Trauma, degenerative disk disease, improper lifting.
    » Commonly affects L-5, S-1 and L-4, L-5 disks.
Spinal stenosis is a narrowing of the spinal canal.
Management of SCI

- Primary goal is the prevention of secondary injury.
- Stabilization of the spine begins in the initial assessment.
  - Treat the spine as a long bone.
    » Immobilize joint above and below.
  - Use caution with “partial” spine splinting.
    » All or None.
- Immobilization vs Motion Restriction.
  - Our Medical Director supports immobilization if the mechanism of injury indicates need.
  - Some patients will not tolerate immobilization on long spine board.
Spinal Evaluation Detailed Exam

- **Conscious patients**
  - Sensory — touch fingers and toes
  - Motor — have patient move fingers and toes

- **Unconscious patients**
  - May withdraw or localize when you pinch fingers and toes

- **Document and repeat every 5 minutes.**
Babinski Reflex

- Positive in adults when the big toe flexes toward the top of the foot and the toes fan out.
- Indicates spinal cord injury or disease to the corticospinal tract.
- Primitive reflex is normal in infants.
UNCONSCIOUS TRAUMA PATIENTS HAVE 15-20% INCIDENCE OF SPINAL INJURY
Management of SCI

- Neutral positioning of the head and neck if at all possible.
  - Allows for the most space for cord.
  - Most stable position for spinal column.
  - Don’t force neutral alignment.
Management of SCI

- Cervical Motion Restriction
  - Manual stabilization maintained.
  - Rigid collar comes later.
  - Manual stabilization continues until torso and head secured to long spine board.
  - “CID”
    » Don’t use sand bags or IV fluid bags as head blocks
    » Tape works wonders!
    » Improvise with blanket rolls
Management of SCI

- Don’t forget the padding
  - Maintains anatomical position
  - Limits movement on board
    » Especially during transport.
    » Or a log-roll to clear airway.
  - Fill all the voids, but don’t create a fulcrum!
    » Curvature of the lower back is normal and will leave a void.
    » Pillows, blankets, towels work well to fill voids.
    » Tape alone (even duct tape) is not enough.
Management of SCI

- Securing the patient to the board.
  - Straps, tape, cravats, whatever works.
  - Torso first, then legs and feet. The head is last.
  - Even patients extricated with a KED are secured to the board.
Management of SCI

- Pediatric patient considerations.
  - SCIWORA. Spinal cord injury without radiologic abnormality.
  - Elevate the entire torso if large occiput.
    - Pad underneath
    - Short board underneath
    - Vacuum mattress
Management of SCI

Pediatric considerations:
- Lots of voids to fill
- Difficult to find a correctly sized rigid collar
  » Improvise with
    - horse collar
    - blanket or towel rolls
Management of SCI

- **Helmeted Patients**
  - Removal should be limited to emergent need for access to airway and ventilation.
  - Leave in place if:
    - It fits with little or no head movement in the helmet.
    - No impending airway or breathing problems.
    - Can perform spinal motion restriction with helmet on.
    - No interference in airway assessment or management.
    - No cardiac arrest.
Management of SCI

Helmeted Patients

- Types of Helmets
  » Sports (football, hockey)
  » Recreational (motorcycle, bicycle)

- Various helmets create different problems for the patient and for removal.
Helmets

- **Patients with football helmets and shoulder pads:**
  - Leave helmet in place but remove face mask to access the airway.
  - Shoulder pads and helmet go together. If one goes, they both go, or pad to maintain neutral position.

- **Motorcycle helmets:**
  - Will usually cause flexion of the neck.
  - Must remove full face helmets to manage the airway.
  - Remove before placing the patient on a backboard.
Management of Spinal Cord Injury

- 100% oxygen.
- Complete spinal immobilization.
- C-spine stabilization maintained with intubation. Delegate someone to be responsible for the airway.
- Load & Go with smooth transport.
- IV fluids to maintain BP of 90 mmHg systolic (with head injury maintain 110 mmHg systolic).
  - If patient remains hypotensive following fluid bolus, initiate a Dopamine infusion starting at 5 mcg/kg/min.
- Pain management accomplished with Fentanyl.
Summary

- Assess the scene for clues of spinal injury.
- Manually immobilize cervical spine.
- Initial Assessment:
  - ABCs.
  - History may provide clues to spinal injury.
  - Check the back.
- Is full spinal immobilization indicated?
  - When in doubt, immobilize.
- Critical interventions.
Questions?