Introduction

- Annually 15,000 permanent spinal cord injuries
- Commonly men 16-30 years old
- Mechanism of Injury
  - MVCs: 50%
  - Falls: 20%
  - Penetrating Trauma: 15%
  - Sport Injuries: 15%

Introduction continued…

- 25% of all spinal cord injuries occur from improper handling of the spine and patient after injury
  - ASSUME based upon MOI that patient’s have a spinal injury
  - Manage ALL spinal injuries with immediate and continued care

More Intro…

- Lifelong care for spinal cord injury victim exceeds $1 million.
- Best form of care is public safety and prevention programs.
Spinal Anatomy and Physiology

Spinal Anatomy
- The spinal cord extends from the midbrain at the base of the skull to the level of L1 or L2 in most adults
- 31 pairs of peripheral nerves (spinal nerves)
  - 8 cervical
  - 12 Thoracic
  - 5 Lumbar
  - 5 Sacral
  - 1 Coccygeal

Spinal Anatomy
- Function
  - Skeletal support structure
  - Major portion of axial skeleton
  - Protective container for spinal cord
- Vertebral Body
  - Major weight-bearing component
  - Anterior to other vertebrae components
Divisions of the Vertebral Column

Cervical Spine

- 7 Vertebrae
- Sole support for head
  - Head weighs 16-22 pounds
  - C1 supports head
  - Security affixed to the occiput
  - Permits nodding

Cervical Spine

- C2
  - Odontoid Process
    - Projects upward
    - Provides pivot point so head can rotate
  - C7
    - Prominent spinous process
Thoracic Spine

- 12 vertebrae
- 1st rib articulates with T1
  - Attaches to transverse process and vertebral body
- Next nine ribs attached to the inferior and superior portion adjacent vertebral bodies
  - Limits rib movement and provides increased rigidity
- Larger and stronger than cervical spine
  - Larger muscles help to ensure that the body stays erect
  - Supports movement of the thoracic cage during respirations

Lumbar Spine

- 5 vertebrae
- Bear forces of bending and lifting above the pelvis
- Largest and thickest vertebral bodies and intervertebral disks
Sacral Spine
- 5 fused vertebrae
- Form posterior plate of pelvis
- Help protect urinary and reproductive organs
- Attaches pelvis and lower extremities to axial skeleton

Coccygeal Spine
- 3-5 fused vertebrae
- Residual elements of a tail

Spinal Meninges
- Layers
  - Dura mater
  - Arachnoid
  - Pia mater
- Cover entire spinal cord and peripheral nerve roots that exit
- CSF fills the subarachnoid space
  - Exchange of nutrients and waste products
  - Absorbs shocks of sudden movement
Spinal Cord

- **Function**
  - Transmits sensory input from body to the brain
  - Conducts motor impulses from brain to muscles and organs
  - Reflex Center: Intercepts sensory signals and initiates a reflex signal

- **Growth**
  - Fetus: Entire cord fills entire spinal foramen
  - Adult: Base of brain to L-1 or L-2 level
  - Peripheral nerve roots pulled into spinal foramen at the distal end (Cauda Equina)

Spinal Nerves

- 31 pairs of nerves that originate along the spinal cord from anterior and posterior nerve roots
  - Sensory & motor functions
  - Travel through intervertebral foramina
  - 1st pair exit between the skull and C-1
  - Remainder of pairs exit below the vertebrae
  - Each pair has 2 dorsal and 2 ventral roots
    - Ventral roots: motor impulses from cord to body
    - Dorsal roots: sensory impulses from body to cord
  - C-1 & Co-1 do not have dorsal roots

### Table 9-1: Spinal Nerve Plexuses

<table>
<thead>
<tr>
<th>Plexus</th>
<th>Origin</th>
<th>Nerve</th>
<th>Cord</th>
<th>Result of Injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical</td>
<td>C1 to C3</td>
<td>phrenic</td>
<td>diaphragm</td>
<td>respiratory paralysis</td>
</tr>
<tr>
<td>Brachial</td>
<td>C5 to C8, T1</td>
<td>axillary</td>
<td>deltoid of shoulder</td>
<td>deltoid muscle paralysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>radial</td>
<td>triceps of arm</td>
<td>wrist drop</td>
</tr>
<tr>
<td></td>
<td></td>
<td>motion</td>
<td>flexor muscles of arm</td>
<td>decreased usage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>musculocutaneous</td>
<td>flexor muscles of arm</td>
<td>decreased usage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ulnar</td>
<td>wrist and hand</td>
<td>claw hand, inability to spread fingers</td>
</tr>
<tr>
<td>Lumbar</td>
<td>T-12 to L-4</td>
<td>femoral</td>
<td>lower abdomen, greater trochanter, thighs</td>
<td>inability to extend leg, flex hip</td>
</tr>
<tr>
<td></td>
<td></td>
<td>obturator</td>
<td>abductor muscles of hip</td>
<td>decreased usage</td>
</tr>
<tr>
<td>Sacral</td>
<td>L-4 to S-5</td>
<td>sacral</td>
<td>lower extremity</td>
<td>decreased usage</td>
</tr>
</tbody>
</table>

**Key Locations of Spinal Nerves**

- **Dermatomes**
  - Topographical region of the body surface innervated by one nerve root
  - Collar region: C-3
  - Little finger: C-7
  - Nipple line: T-4
  - Umbilicus: T-10
  - Small toe: S-1
Key Locations continued…

Myotomes
Muscle and tissue of the body innervated by spinal nerve roots
- Arm extension: C-5
- Elbow extension: C-7
- Small finger abduction: T-1
- Knee extension: L-3
- Ankle flexion: S-1

Spinal Nerves

Reflex Pathways
- Function
  - Speeds body's response to stressors
  - Reduces seriousness of injury
  - Body stabilization
- Occur in special neurons
  - Interneurons
- Example
  - Touch hot stove
  - Severe pain sends intense impulse to brain
  - Strong signal triggers interneuron in the spinal cord to direct a signal to the flexor muscle
  - Limb withdraws without waiting for a signal from the brain

Subdivision of ANS
- Parasympathetic “Feed & Breed”
  - Controls rest and regeneration
  - Peripheral nerve roots from the sacral and cranial nerves
  - Major Functions
    - Slows heart rate
    - Increase digestive system activity
    - Plays a role in sexual stimulation
- Sympathetic “Fight or Flight”
  - Increases metabolic rate
  - Branches from nerves in the thoracic and lumbar regions
  - Major Functions
    - Decrease organ and digestive system activity
    - Vasoconstriction
    - Release of epinephrine and norepinephrine
    - Systemic vascular resistance
      - Reduce venous blood volume
      - Increase peripheral vascular resistance
    - Increases heart rate
    - Increase cardiac output
Pathophysiology of Spinal Injuries

Types of Injuries

Mechanisms of Spinal Injuries

- Extremes of motion
  - Hyperextension
  - Hyperflexion: “Kiss the Chest”
  - Excessive Rotation
  - Lateral bending
- Axial Stress
  - Axial loading
  - Compression common between T12 and L1
  - Distraction
  - Combination
  - Distraction/Rotation or compression/flexion
- Other MOI
  - Direct, Blunt or Penetrating trauma
  - Electrocrution

Spinal Column Injuries

- Movement of vertebrae from normal position
- Subluxation or Dislocation
- Fractures
  - Spinous process and Transverse process
  - Vertebral body
  - Ruptured intervertebral disks
- Common sites of injury
  - C-1/C-2: Delicate vertebrae
  - C-7: Transition from flexible cervical spine to thorax
  - T-12/L-1: Different flexibility between thoracic and lumbar regions
Spinal Cord Injuries

- Concussion
  - Similar to cerebral concussion
  - Temporary and transient disruption of cord function
- Contusion
  - Bruising of the cord
  - Tissue damage, vascular leakage and swelling
- Compression
  - Secondary to:
    - Displacement of the vertebrae
    - Herniation of intervertebral disk
    - Displacement of vertebral bone fragment
    - Swelling from adjacent tissue

Spinal Cord Injuries continued...

- Laceration
  - Causes
    - Bony fragments driven into the vertebral foramen
    - Cord may be stretched to the point of tearing
  - Hemorrhage into cord tissue, swelling and disruption of impulses
- Hemorrhage
  - Associated with contusion, laceration, or stretching

SPINAL CORD TRANSECTION (COMPLETE)

Injury that partially or completely severs the spinal cord

- Complete
  - Cervical Spine
    - Quadriplegia
    - Incontinence
    - Respiratory paralysis
  - Below T-1
    - Incontinence
    - Paraplegia
SPINAL CORD TRANSECTION (INCOMPLETE)

Anterior Cord Syndrome
- Anterior vascular disruption
- Loss of motor function and sensation of pain, light touch, & temperature below injury site
- Retain motor, positional and vibration sensation

Central Cord Syndrome
- Hyperextension of cervical spine
- Motor weakness affecting upper extremities
- Bladder dysfunction

Brown-Sequard’s Syndrome
- Penetrating injury that affects one side of the cord
- Ipsilateral sensory and motor loss
- Contralateral pain and temperature sensation loss

Signs and Symptoms of a Spinal Cord Injury
- Extremity paralysis
- Pain with & without movement
- Tenderness along spine
- Impaired breathing
- Spinal deformity
- Priapism
- Posturing
- Loss of bowel or bladder control
- Nerve impairment to extremities

NEUROGENIC SHOCK SYMPTOMS

- Bradycardia
- Hypotension
- Cool, Moist & Pale skin above the injury
- Warm, Dry & Flushed skin below the injury
- Male: Priapism

Patient Assessment
INITIAL ASSESSMENT

➢ Scene Size-up
  • Evaluate MOI
  • Determine type of spinal trauma
  • Maintain suspicion with sports injuries
  • If unclear about MOI take spinal precautions

Assessment of a Spinal Injury Patient

➢ Consider spinal precautions
  ■ Head injury
  ■ Intoxicated patients
  ■ Injuries above the shoulders
  ■ Distracting injuries
➢ Maintain manual stabilization
  ■ Vest style versus rapid extrication
  ■ Maintain neutral alignment
  ■ Increase of pain or resistance, restrict movement in position found

Rapid Assessment

➢ Focused versus Rapid Assessment
➢ Rapid Assessment
  ■ Suspected or likely spinal cord/column injury
  ■ Multi-system trauma patient
  ■ Evaluate for
    • Neck
    • Deformity, Pain, Crepitus, Warmth, Tenderness
    • Bilateral Extremities
    • Finger Abduction/Adduction
    • Push, Pull, Grips
    • Motor & Sensory Function
    • Dermatome & Myotome evaluation
    • Babinski Sign Test
    • Hold-Up Position

BABINSKI TEST

➢ Stroke lateral aspect of the bottom of the foot
➢ Evaluate for movement of the toes
  Fanning and Flexing (lifting)
  ■ Positive sign
    Injury along the pyramidal (descending spinal) tract
Assessment continued…

- **Vital Signs**
  - Body Temperature
  - Pulse
  - Blood Pressure
  - Respiration

Ongoing Assessment

- Recheck elements of initial assessment
- Recheck vital signs
- Recheck interventions
- Recheck any neurological deviations

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**NEXUS**

- National Emergency X-Radiography Utilization Study
- Multi-center study that has been going on since 1998
- Initial report of 34,069 pts:
  - 2.4% sustained cervical spine injury
  - 6% sustained thoracic/lumbar spine injury

**More NEXUS**

- 5 criteria used to “clear” c-spine
  - Midline cervical tenderness
  - ALOC
  - Evidence of intoxication
  - Neurologic abnormality
  - Presence of distracting injury
Results

- Of the initial 34,069 pts 818 were found to have CSI. All but 8 of those with CSI and all but 2 of the 578 with significant CSI were identified by using these criteria.
- By using ALL 5 criteria 99.8% of the pts with cervical spine injury were identified.
- This is similar in accuracy to pregnancy tests, EKG's!

Management of the Spinal Injury Patient

Spinal Immobilization

- Move patient to a neutral, in-line position
- Position of function:
  - Hips and knees should be slightly flexed for maximum comfort and minimum stress on muscles, joints, & spine
  - Place a rolled blanket under the knees
- ALWAYS support the head and neck
- Contraindications to neutral position:
  - Movement causes a noticeable increase in pain
  - Noticeable resistance met during procedure
  - Increase in neurological deficits occurs during movement
  - Gross deformity of spine
- LESS MOVEMENT IS BEST

Manual C-Spine

- In supine adult pt head should be slightly elevated ~1-2" to maintain in line position
- In supine pediatric pt shoulders should be slightly elevated to maintain in line position
  - Remember that the occiput in children and overall size of the head is a greater proportion to that of adults
Treatment
- ABC’s
- Suction
- Oxygen
- Consider appropriate airway management
- Consider Intubation if required (ILS/ALS)
- Consider IV Therapy (ILS/ALS)

Fluid Challenge
- Isotonic Solution: 20 mL/kg
  - 250 mL initially
  - Monitor response and repeat as needed

Maintain in-line manual c-spine control

Treatment continued...
- PASG
  - Controversial
    - Research shows no positive outcome

In a perfect world...
- Your pt will be calm and do EXACTLY what you tell them to do!!
- But alas...they do not.

PATIENT MOVEMENT REVIEW
- Any movement MUST be coordinated
- Place back board ~1-2 feet higher than pts head
- Move patient as a unit
- NO LATERAL PUSHING
  - Move patient up and down to prevent lateral bending
- Rescuer at the head "CALLS" all moves
- ALL MOVES MUST be slowly executed and well coordinated
- Consider the final positioning of the patient prior to beginning move
TYPES OF MOVES FOR SPINAL INJURY PATIENTS

- Log Roll
- Straddle Slide
- Rapid Extrication
- Final Patient Positioning
- Long Spine Board
- Diving Injury Immobilization

Cervical Immobilization

Seated Patient
- Approach from front
- Assign a care giver to hold GENTLE manual traction
- Evaluate posterior cervical spine
- Position patient’s head slowly to a neutral, in-line position

Supine Patient
- Assign a care giver to hold GENTLE manual traction
- Adult
  - Lift head off ground 1-2": Neutral, in-line position
  - Child
    - Position head at ground level: Avoid flexion

CERVICAL COLLAR APPLICATION

- Apply the c-collar as soon as possible
- Assess neck prior to placing
- C- Collar limits some movement and reduces axial loading
- DOES NOT completely prevent movement of the neck
- Size and Apply according to the Manufacturer’s Recommendation
  - Collar should fit snug
  - Collar should NOT impede respirations
  - Head should continue to be in neutral position
  - DO NOT RELEASE manual control until the patient is fully secured in a spinal restriction device

General Rules for C-Collars

- Measure from the top of the pts shoulder to the lower mandible for correct sizing
- Most pts necks are NOT "No Necks"
- Padding of the c-collar should be slightly flattened and exploded on pts shoulders
- C-collar should NOT wiggle after application!
Helmet Removal

Technique
- 2 Rescuers
- Have a plan
- Remove face mask and chin strap
- Immobilize head
  - Slide one hand under back of neck and head
  - Other hand supports anterior neck and jaw
- Remove helmet
  - Gently rock head to clear occiput
- All actions should be slow and deliberate

TRANSPORT HELMET with patient

On the Streets

You are dispatched to the home of an 80-year-old female who fell in the bathroom and is c/o left hip pain. She presents laying partially in the bathtub and has a small hematoma over her left eye. Her daughter tells you that her only past medical history is Osteoporosis and she is handing you a bag of medicine bottles and also tells you that she has no allergies. While you are talking to the daughter your partner moves into the bathtub to provide manual c-spine immobilization. As he is placing his hands in position the patient says “that hurts my neck.”

On the Streets continued…

- What should your first priority be?
- How will you accomplish this?
- What is your course of treatment?
- What will be the best way to move this patient?
- Should you be concerned about her hip pain? If so, what will you do?
QUESTIONS?

Just a note…

- One retrospective study evaluated 569 patients in the United Kingdom with proven spinal cord injury during a nine-year period and found that the injury was “missed” in 52 of those cases.
- In 26 of those patients, mismanagement resulted in neurologic deterioration.

What is the key point in this note?

Secret Question

You are responding to the scene of a t-bone MVA. A sports car traveling at ~30 MPH hit a SUV on the driver’s door. Upon your arrival first responders are attending to the driver of the sports car and report that he has sustained very mild injuries. The driver of the SUV is c/o RLQ abdominal pain and has an obvious fracture of the left forearm. Upon initial exam the pt has midline tenderness from C2-T10. What is the proper course of treatment for this pt?

A. Manual c-spine immobilization, rapid extrication through the passenger side door, splint the left forearm, secure pt to backboard, v/s, transport

B. Apply KED, v/s, manual c-spine immobilization, remove pt through passenger side door, transport, secure pt to backboard, reassess v/s and CSM

C. Manual c-spine immobilization, v/s and CSM evaluation, apply KED, remove pt through passenger side door, secure pt to backboard, reassess v/s and CSM, transport

D. Assess v/s, manual c-spine, insert NPA, apply KED, remove pt through passenger side door, reassess v/s and CSM, secure pt to backboard, transport

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