Citation Key

for more information see: http://open.umich.edu/wiki/CitationPolicy

Use + Share + Adapt

{ Content the copyright holder, author, or law permits you to use, share and adapt. }

Public Domain – Government: Works that are produced by the U.S. Government. (USC 17 § 105)

Public Domain – Expired: Works that are no longer protected due to an expired copyright term.

Public Domain – Self Dedicated: Works that a copyright holder has dedicated to the public domain.

Creative Commons – Zero Waiver

Creative Commons – Attribution License

Creative Commons – Attribution Share Alike License

Creative Commons – Attribution Noncommercial License

Creative Commons – Attribution Noncommercial Share Alike License

GNU – Free Documentation License

Make Your Own Assessment

{ Content Open.Michigan believes can be used, shared, and adapted because it is ineligible for copyright. }

Public Domain – Ineligible: Works that are ineligible for copyright protection in the U.S. (USC 17 § 102(b)) *laws in your jurisdiction may differ

{ Content Open.Michigan has used under a Fair Use determination. }

Fair Use: Use of works that is determined to be Fair consistent with the U.S. Copyright Act. (USC 17 § 107) *laws in your jurisdiction may differ

Our determination **DOES NOT** mean that all uses of this 3rd-party content are Fair Uses and we **DO NOT** guarantee that your use of the content is Fair.

To use this content you should **do your own independent analysis** to determine whether or not your use will be Fair.

Advanced Emergency Trauma Course

C-Spine and Spinal Cord Trauma

Presenter: Carl Seger, MD

Ghana Emergency Medicine Collaborative

Patrick Carter, MD • Daniel Wachter, MD • Rockefeller Oteng, MD • Carl Seger, MD

Epidemiology

- Spinal Trauma- 10,000 new cases each year, with over 200,000 spinal injury victims living in US
- 55% of spinal injuries occur in the C-spine
- 15% in the thoracic, lumbar, and sacral regions
- 10% of pts with c-spine injury have another vertebral fracture

Spinal Trauma

- Spinal trauma has a huge impact physically, financially, and emotionally on society
- Proper treatment can minimize further damage
- Immobilization equipment is easy to use, inexpensive, and readily available
- Our duty as EM physicians is to provide proper care and “Do No Harm”

Can we make an impact?

- “3-25% of cases of permanent neurologic impairment after spinal trauma have been attributed to injudicious manipulation by paramedical personnel, examining physicians, or radiology technicians.”

Francisco de Assiss Aquino Gondim, MD, e-medicine- *Spinal Cord Trauma*

Prevention is key!

- With proper application of spinal precautions, we can positively impact patient outcomes

Evolution of Spine

- Prehistoric Man
  - Hunched shoulders
  - Strong posterior neck muscles
- Modern Man
  - Shoulders drop away, head elevates
  - Atrophy paraspinal muscles
  - Sacrifice protection for increased range of motion

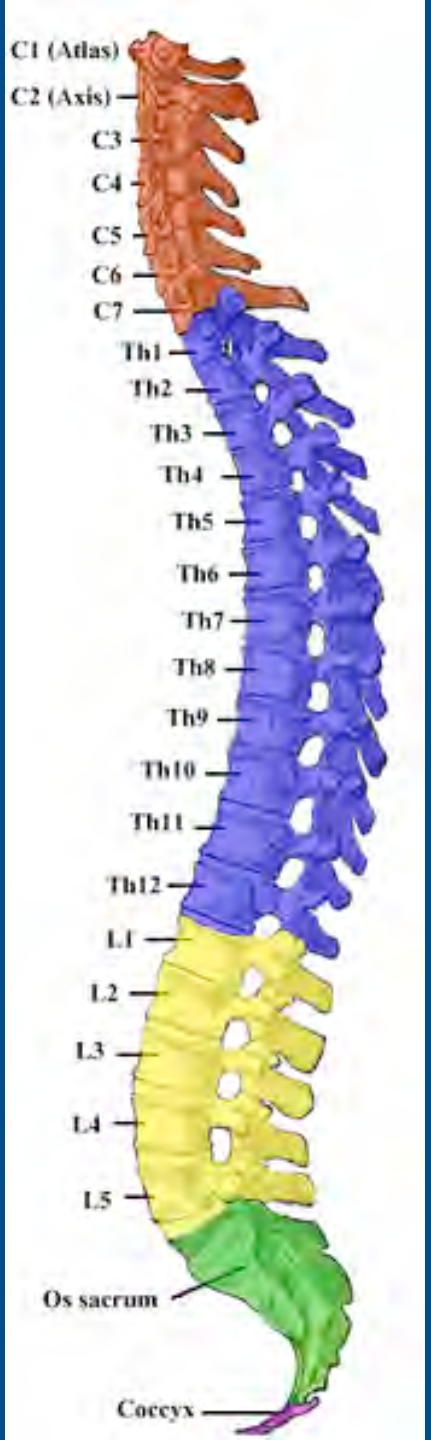
Modern Man

- Increased Intellect, same aggression
- Horse drawn carriages replaced by machine-powered vehicles
- Fists and clubs gave way to knives and guns
- New and inventive ways to inflict injury to spine

Basic Anatomy

- 7 Cervical
- 12 Thoracic
- 5 Lumbar
- 5 Sacral
- 4 Fused
- Coccygeal

- Lordotic Curves
- Kyphyotic Curves



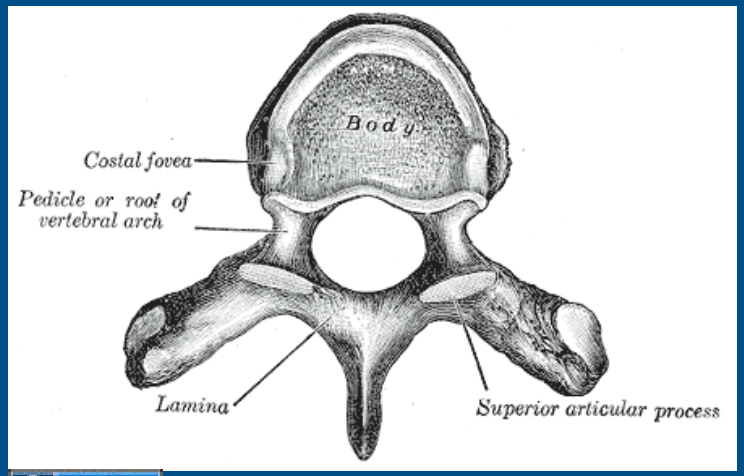
PD-EXP

Gray's Anatomy (Wikipedia)

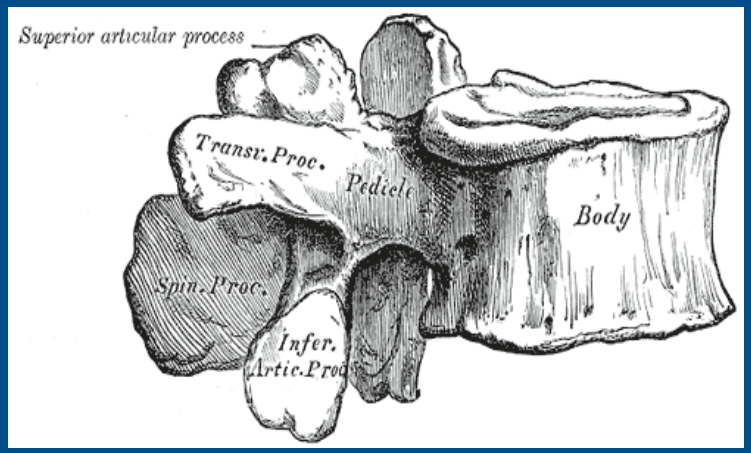
Functional Anatomy Review

- Vertebral Column
  - 33 Vertebrae

- Vertebrae = Body + Arch
  - Vertebral Arch
    - Pedicles
    - Laminae
    - Processes



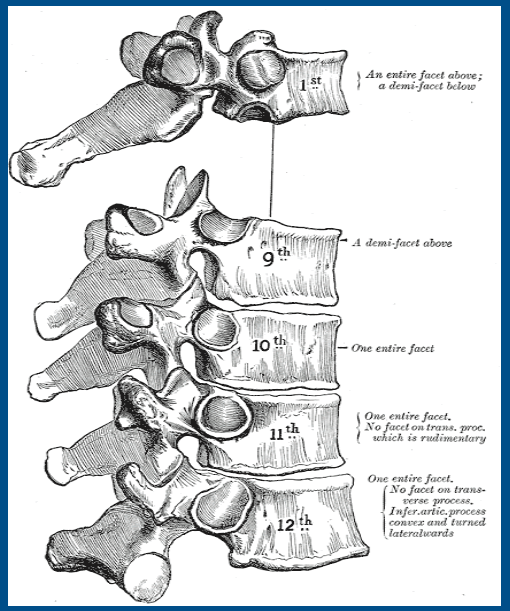
PD-EXP Gray' s Anatomy (Wikipedia)



PD-EXP Gray' s Anatomy (Wikipedia)

Functional Anatomy Review

- Ligaments
  - Anterior/Posterior Longitudinal
  - Vertebral Arch Ligaments
    - Ligamentum Flavum
    - Supraspinatous Ligament
    - Interspinous Ligament
    - Intertransverse Ligament
    - Capsular Ligament
- Intervertebral Disks
  - Nucleus Propulsus
  - Annulus Fibrosus

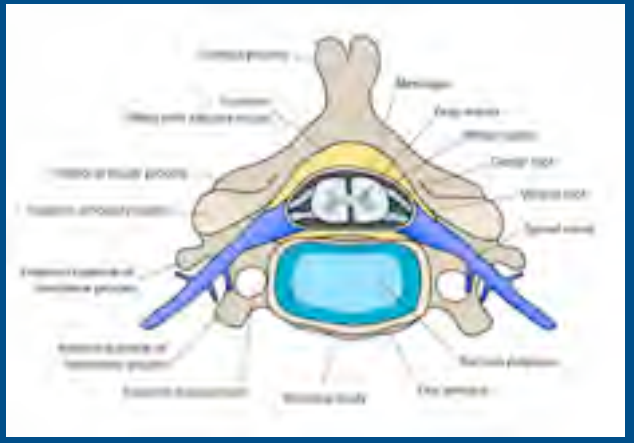


PD-EXP Gray' s Anatomy (Wikipedia)

BY-SA Uwe Gille (Wikipedia)

Spinal Stability

- Cervical Spine
  - Anterior Column
  - Posterior Column
  - Disrupt both columns to be unstable
- Thoracolumbar Spine
  - Denis Classification
  - Anterior Column
  - Middle Column
  - Posterior Column
  - Disrupt 2 columns to be unstable



https://commons.wikimedia.org/wiki/File:Cervical_vertebra_english.png

Gray's Anatomy (Wikipedia)

Normal Cervical Spine

PD-INEL http://www.trauma.org/archive/spine/images/cspineLAT.jpg

PD-INEL http://www.trauma.org/archive/spine/images/cspinealign.jpg

Injury Patterns

- Acute spinal injuries can be most easily classified according to the mechanism of trauma
- Categories include FLEXION, FLEXION-ROTATION, EXTENSION and VERTICAL COMPRESSION injuries
- Can also include in classification whether or not a particular injury is STABLE vs. UNSTABLE

Cervical Spine Injuries

- Flexion Injuries
  - Wedge compression fracture
  - Flexion teardrop fracture
  - Clay Shoveler's Fracture
  - Bilateral Facet Dislocation
- Flexion Rotation
  - Unilateral facet dislocation
- Vertical Compression
  - Jefferson Burst Fracture
  - Burst Fractures of Lower Cervical Spine
- Hyperextension Injuries
  - Avulsion fracture of anterior arch of atlas
  - Extension teardrop fracture
  - Posterior arch of atlas fracture
  - Laminar fracture
  - Hangman's Fracture
- Lateral Flexion
  - Uncinate Process Fracture
- Upper C-spine Injuries
  - Occipitoatlantal dissociation

Flexion Injuries

- Flexion injuries involving C1-C2 can cause atlantooccipital or atlantoaxial dislocation, with or without fracture of the odontoid
- Atlas = C1, Axis = C2
- Unstable due to the location and relative lack of muscle and ligamentous support

Flexion injury

PD-INEL Source Undetermined

PD-INEL Source Undetermined

- Odontoid Fx with anterior dislocation

Flexion Injury

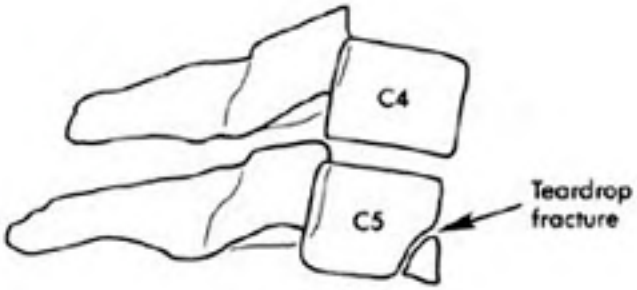
- In pure flexion injury below C2, force is expended on the vertebral body anteriorly, resulting in a simple wedge fracture
- Simple wedge fractures are stable
- Even greater flexion forces a wedge shaped fragment off anterior-inferior portion of vertebral body, called a flexion teardrop injury
- Usually includes ligamentous injury and is unstable

Wedge Fracture

http://faculty.washington.edu/alexbert/MEDEX/Winter/EM1DisordersSpine.htm
http://emedicine.medscape.com/article/94234-media

Flexion Teardrop Fracture

PD-INEL Source Undetermined



PD-INEL Source Undetermined

Flexion Injury

- In Australia during the 1930's, certain clay miners sustained a unique injury
- While straining with heavy shovelful of clay, the abrupt flexion of head in opposition to the strong supraspinous ligament, resulted in avulsion fracture of spinous process
- Clay Shoveler's fracture is more often seen today due to direct blow, i.e. pool cue or baseball bat, or from sudden deceleration in MVC
- Stable injury, no neurologic involvement

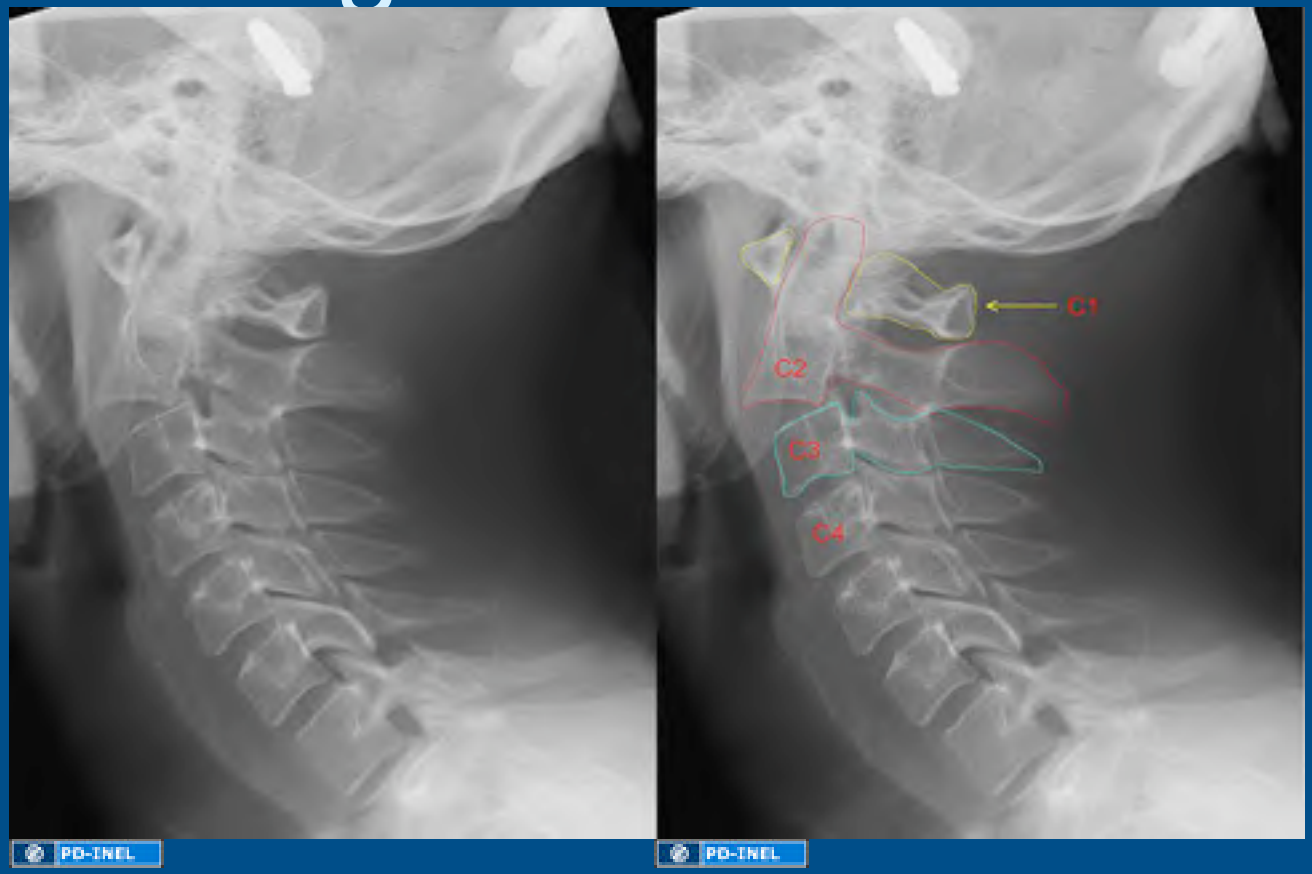
Clay Shoveler's

http://faculty.washington.edu/alexbert/MEDEX/Winter/EM1DisordersSpine.htm http://emedicine.medscape.com/article/94234-media

Extension Injury

- Most well known is the Hangman's fracture
- Popular execution style in previous eras
- "Short Drop with Sudden stop". The drop was preferred to the dangle
- The skull is thrown into extreme hyperextension resulting in bilateral pedicle fractures of axis
- Unstable, but neurological involvement is minimal, therefore death usually due to strangulation, not cord damage

Hangman's Fracture

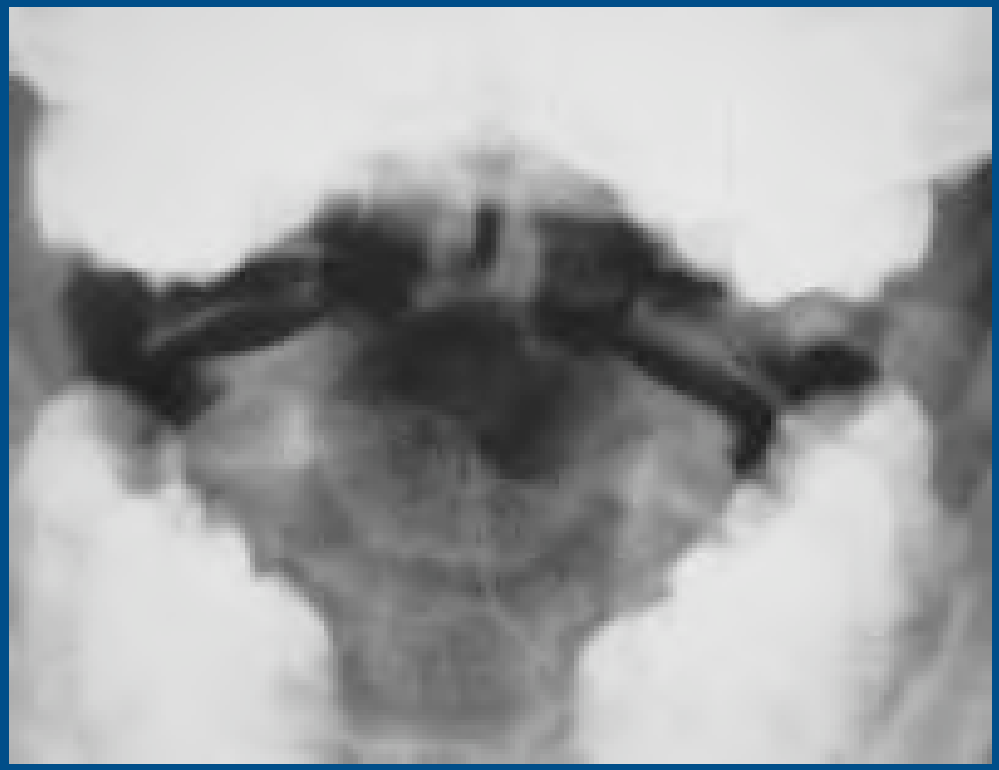


http://commons.wikimedia.org/wiki/File:Hangman%27s_fracture.JPG

Vertical Compression Injury

- Example = Jefferson Fracture
- Force is transmitted down through skull and occipital condyles to superior articular surfaces of lateral masses of atlas
- Since atlas is a ring, this force pushes the masses outward resulting in fractures of anterior and posterior arches, and disruption of transverse ligament
- Extremely **UNSTABLE**

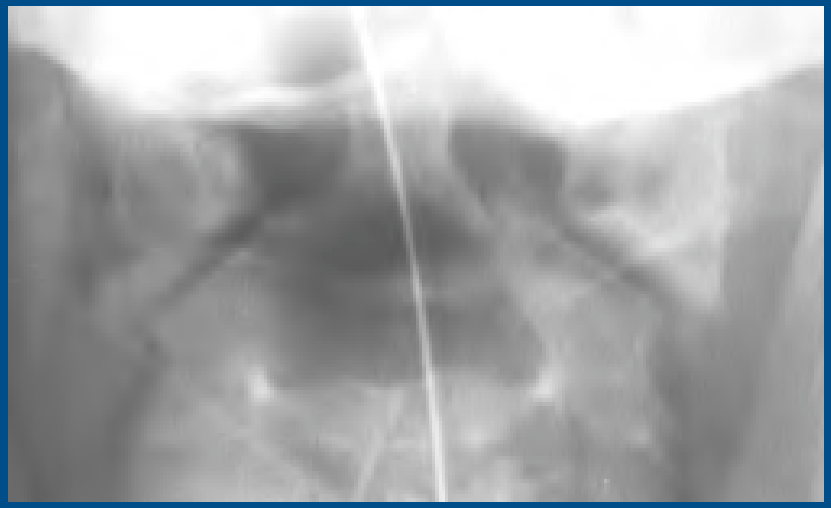
Jefferson Fracture



PD-INEL Source Undetermined

Jefferson Fracture

PD-INEL Source Undetermined



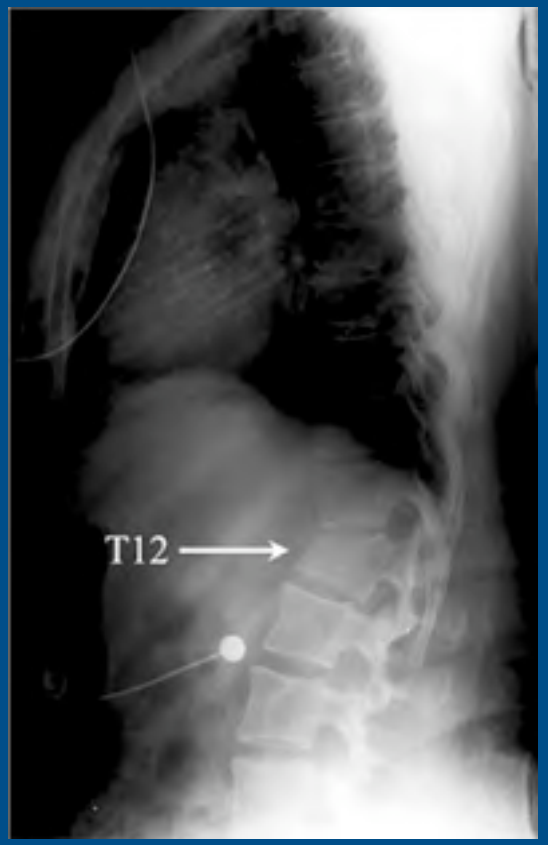
PD-INEL Source Undetermined

Injuries of Thoracic and Lumbar Spine

- Compression Fractures
- Burst Fractures
- Flexion Distraction Fractures

Injuries of Thoracic and Lumbar Spine

- Compression Fractures

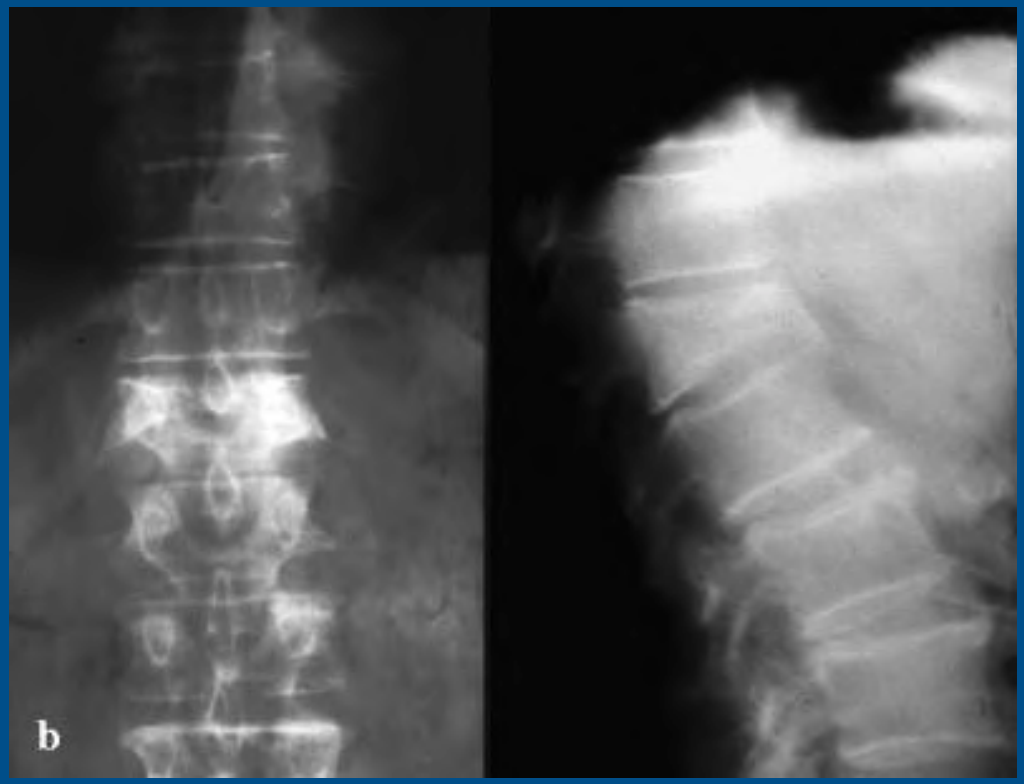


PD-INEL

http://emedicine.medscape.com/article/397896-media

Injuries of Thoracic and Lumbar Spine

- Burst Fractures



PD-INEL http://emedicine.medscape.com/article/248236-media

Injuries of Thoracic and Lumbar Spine

- Flexion Distraction Fractures – Chance Fx

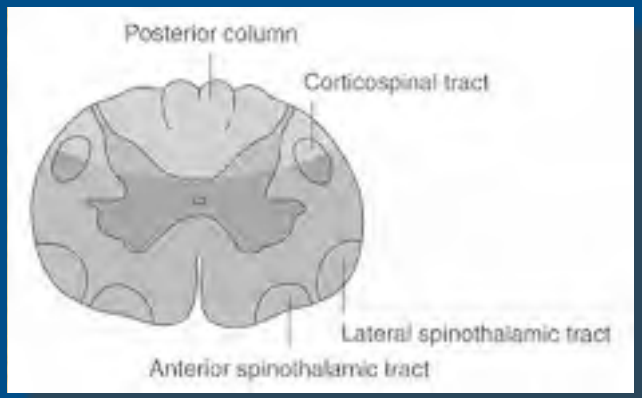
PD-INEL http://radiopaedia.org/images/143729

Pathophysiology of Acute Fractures

- Direct compression of neural elements by bone fragments, disc material, and ligaments leads to damage of the central and peripheral nervous system
- Blood vessel compression and disruption causes ischemia
- Massive cord swelling happens within minutes at the level of injury and leads to secondary ischemia

Spinal Cord Lesions

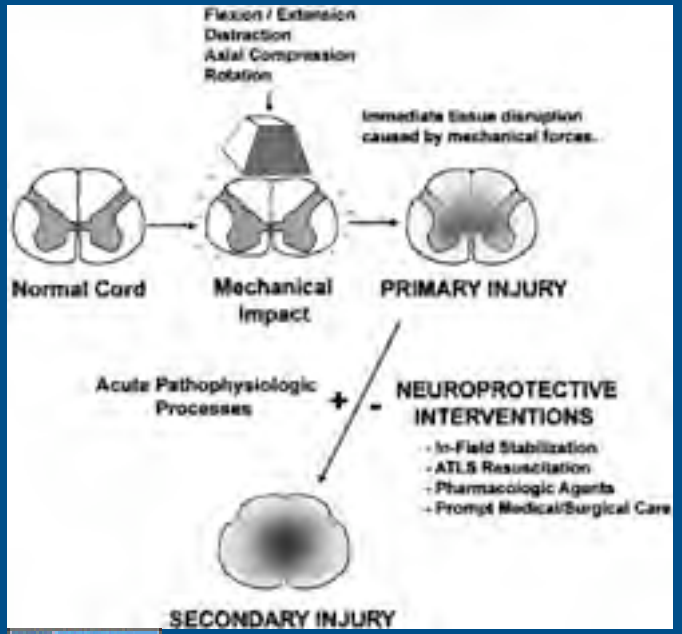
- Overview
  - Complete SCI = No motor or sensory function below injury level
  - Incomplete SCI = Any Sensory/motor function below level of injury
- Spinal Cord Tracts
  - Corticospinal tract = Descending motor pathway
  - Spinothalamic tract (anterior)= Pain/Temperature
  - Dorsal Column Pathway = Vibratory/Proprioception
- Incomplete spinal cord lesions
  - Anterior spinal cord syndrome
  - Posterior spinal cord syndrome
  - Central Cord syndrome
  - Brown Sequard Syndrome



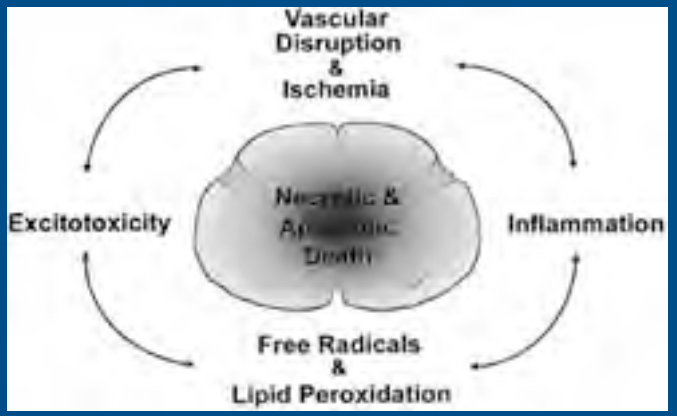
PD-INEL Source Undetermined

Pathophysiology

- Primary Injury
  - Mechanical Injury
- Secondary Injury
  - Vascular Abnormalities
  - Free Radicals/Lipid Peroxidation
  - Excitotoxicity
    - Electrolyte disturbances
  - Inflammation
- Edema



PD-INEL Source Undetermined



PD-INEL Source Undetermined

Cord Syndromes

- Central Cord Syndrome
- Anterior Cord Syndrome
- Posterior Spinal Cord Syndrome
- Brown Sequard Syndrome

Incomplete Spinal Cord Syndromes

- Anterior Spinal Cord Syndrome
  - Corticospinal and spinothalamic tracts injured
  - Preservation of posterior column pathway
  - Etiology
    - Anterior spinal cord trauma
    - Flexion of cervical spine causing cord contusion
    - Thrombosis of anterior spinal artery

PD-INEL Source Undetermined

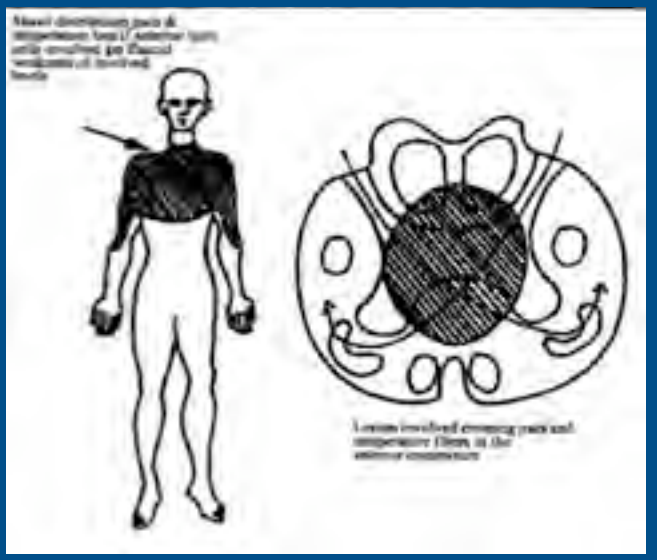
Incomplete Spinal Cord Syndromes

- Posterior Spinal Cord Syndrome
  - Rare condition
  - Injury to dorsal column
  - Preservation of corticospinal and spinothalamic pathways
  - Etiology
    - Penetrating trauma to posterior aspect of cord
    - Hyperextension injury with vertebral arch fracture

PD-INEL Source Undetermined

Incomplete Spinal Cord Syndromes

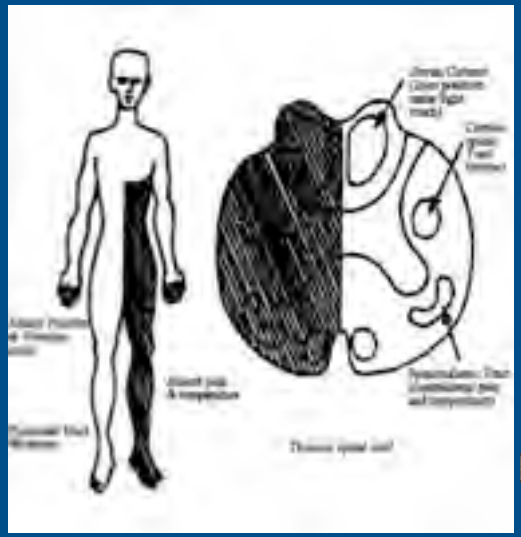
- Central Cord Syndrome
  - Injury preferentially affects central portion of cord
  - Loss of function of central fibers of corticospinal and spinothalamic tracts
  - Decreased strength and pain/ temperature of upper extremities compared with lower extremities
  - Etiology
    - Hyperextension injuries
    - Central spinal stenosis
    - Disruption of normal blood flow



PD-INEL Source Undetermined

Incomplete Spinal Cord Syndromes

- Brown Sequard Syndrome
  - Transverse hemisection of spinal cord
  - Ipsilateral loss of motor function, proprioceptive/vibratory sensation
  - Contralateral loss of pain/temperature sensation
  - Etiology = Penetrating injury or Lateral cord compression



Source Undetermined

Spinal vs. Neurogenic Shock

- Spinal Shock
  - Temporary phenomenon characterized by loss of all spinal cord function caudal to level of injury
  - Symptoms = Flaccid paralysis, Hypotonia, Areflexia, Priapism
  - Typical duration = 24-72 hours
  - Resolution = Return of Bulbocavernosus reflex
  - Outcome = Spastic paresis, hyper-reflexia
- Neurogenic Shock
  - Type of distributive shock characterized by loss of adrenergic tone due to sympathetic denervation
  - Classic Triad = Hypotension, Bradycardia, Hypothermia
  - Management = IVF, Vasopressor support, Atropine

Spinal Shock vs. Neurogenic Shock

- Spinal Shock- the flaccidity and loss of reflexes seen after spinal cord injury. The cord may appear destroyed but actually may regain function latter
- Neurogenic Shock- destruction of the descending sympathetic pathways of the spinal cord. Results is hypotension and bradycardia. Pts will require vasopressors and atropine as well as fluid.

Management

- Immobilization
- Clinical C-spine Clearance
  - When to get images
- Thoracic and Lumbar Spinal Immobilization and Clearance
- Management of Cervical and Thoracolumbar fractures without spinal cord injury

Aims of Immobilization

- Prevent further damage - Protect the Cord
- Hold the spine in a comfortable, anatomically correct way
- Prevent movement of the spine
- Allow for safe concurrent management of other injuries

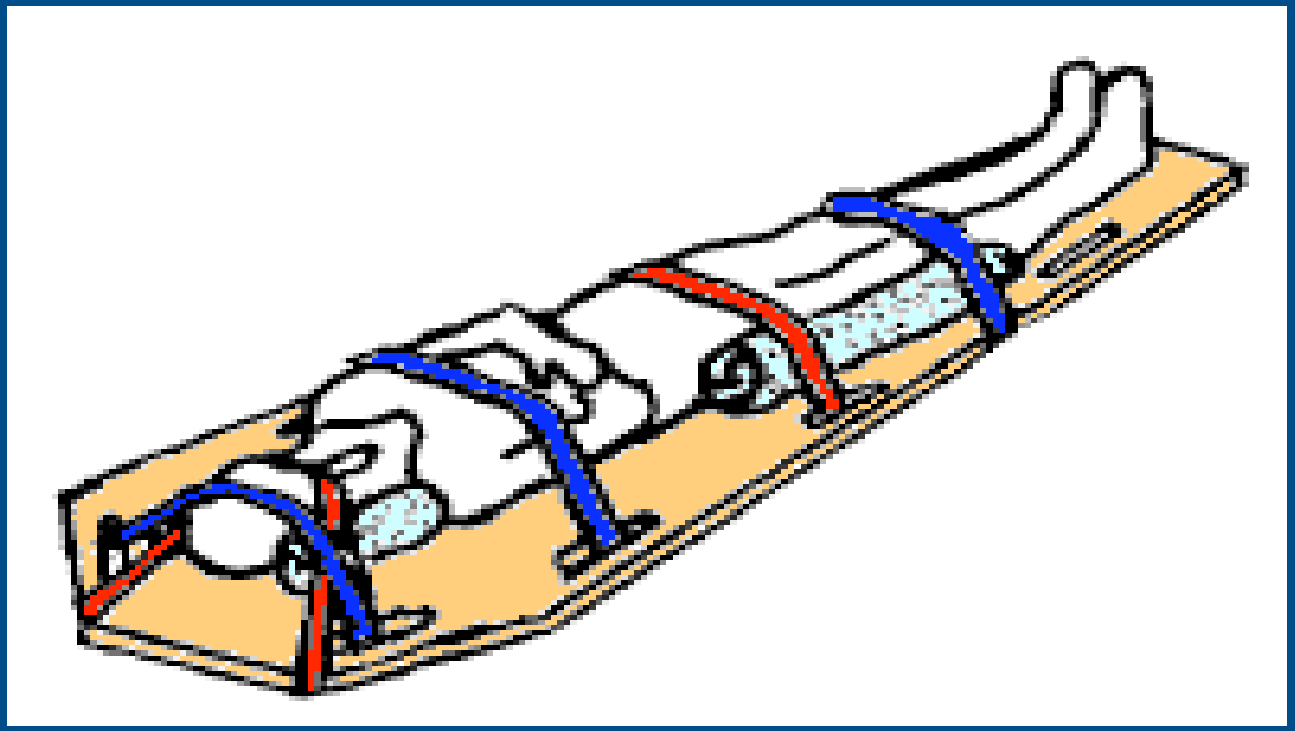
Options for Immobilization

- Anatomical Regions
  - Head
  - Neck
  - Body

Head Immobilization

- Manual - Hands, Legs
- Simple Assist Devices - Sandbags, Towels, Foam Pads
- Additional Devices - Straps
- Head/Neck immobilizer

Head Immobilization



 Cdang (Wikipedia)

Head Immobilization

- Study compared 3 methods during simulated vehicle motion, (Spine 1999;24)
  - Sandbags
  - Headband
  - Styrofoam wedges
- Wedges slightly better
- Key is body immobilization

Neck Immobilization

- Collars
  - Philadelphia
  - Stiffneck
  - Other options

Neck Immobilization

Emrgmgmtca (Wikipedia)

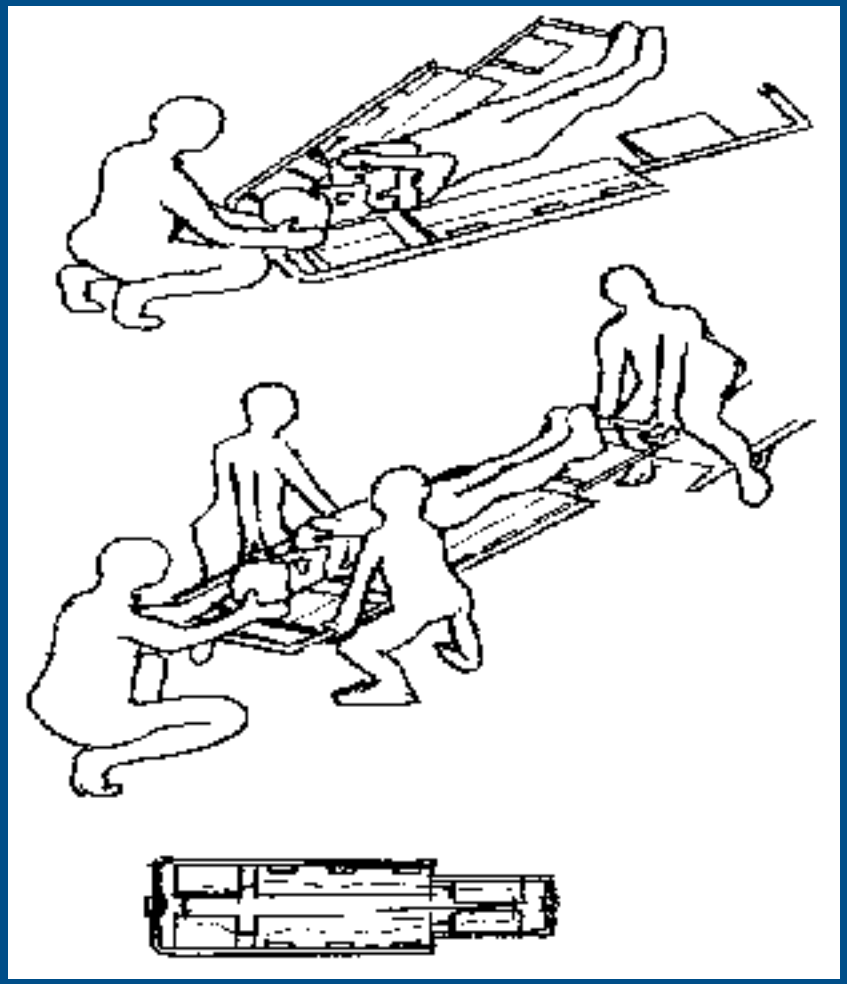
Neck Immobilization

- Ann Emerg Med 1992; 21: 1185-1188
  - Compared C collar with Ammerman Halo orthosis, with and without spine board
  - Photographic comparison during transport
  - **Conclusion:**
    - A rigid cervical collar and a spine board provide significantly better immobilization than the collar alone. Further immobilization is provided by an Ammerman halo orthosis

Body Immobilization

- Backboards
  - Important for transporting patients and keeping them from possibly injuring themselves further

Back Boards



BY-SA Cdang (Wikipedia)

PD-GOV Ryan.mco (Wikipedia)

Complications associated with Spinal Immobilization

- Pain
- Increased risk of pressure sores
- Aspiration and limited respiratory function
  - Increased risk of aspirating emesis while strapped on backboard
  - Marked pulmonary restrictive effect of appropriately applied entire body spinal immobilization devices

When to get an X-ray

- Patients involved in a traumatic event
  - with midline tenderness
  - With neurologic deficits
  - Altered level of consciousness
  - Patients who are intoxicated

C-spine X-ray

- Lateral View
  - Must see to the top of T1 for film to be adequate
  - May need swimmers view
  - Will see 90% of cervical spine fractures
- Odontoid view
  - Must include entire process and right and left c1 and c2 articulations

Flexion and Extension Films

- Obtained in injured pts without an AMS, and pts who have neck pain without fracture on AP, Lateral and odontoid views
- Looking for
  - Instability
  - Ligamentous spine injury

CT Scan

- More Sensitive
- If high suspicion for injury and have inadequate x-ray, CT is warranted

How do you clear a C-spine Injury?

- Two studies- NEXUS vs. Canadian C spine
  - Nexus
    - Patients required to meet 5 criteria
      - No mid-line tenderness
      - No focal neurological deficit
      - Normal alertness
      - No intoxication
      - No painful, distracting injury

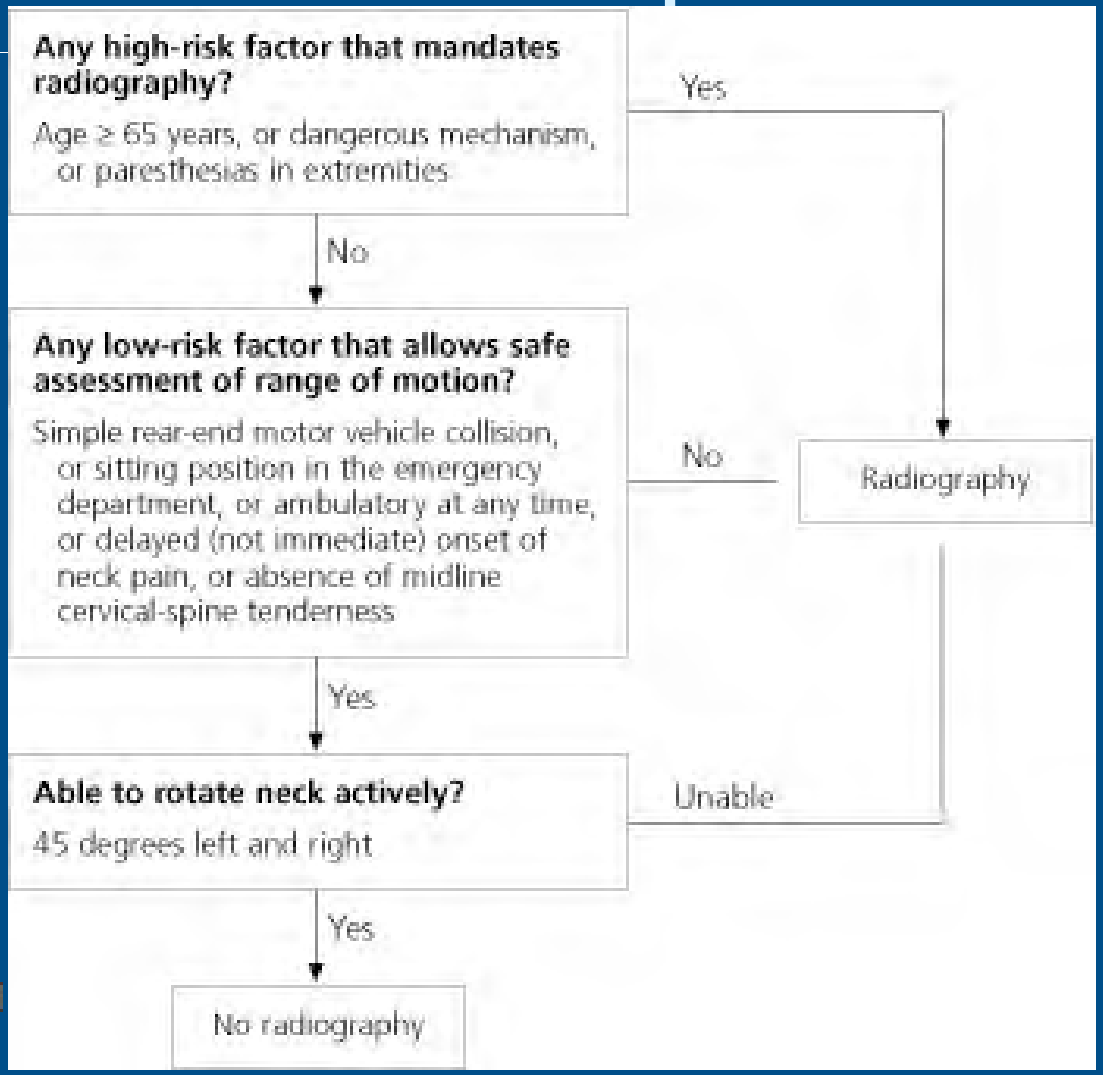
NEXUS study

- Patients who underwent C-spine X-ray for blunt trauma
- 34,069 patients included in study
- 818 patients had a C-spine injury
- 8 of these patients met all 5 criteria
- 4209 non-injured patients met all 5 criteria

NEXUS Study

- Problems
  - Management stressors
  - Failure to discriminate what pain is significant
  - What is a distracting injury?
  - How drunk is intoxicated?

Canadian C Spine Rule



Canadian C Spine Rule

- The authors conclude that the CCR decision rule is more sensitive than NEXUS for identification of clinically important C-spine injuries and also is more specific, thereby decreasing the number of unnecessary C-spine radiographs
- Problems include
  - Requires active neck rotation (10% excluded)
  - What is a “Dangerous Mechanism”?

Methylprednisolone

- Controversial treatment modality for blunt spinal cord trauma
- National Acute Spinal Cord Injury Studies (NASCIS)
- Subsequent studies
  - Pointillart (2000)
  - Matsumoto (2001)
- Mechanism of Action
  - Inhibition of free radical induced lipid peroxidation
- Current recommended regimen
  - Methylprednisolone prescribed as a bolus intravenous infusion of 30 mg/kg of body weight over 15 min within 8 hours of acute closed spinal cord injury
  - Followed 45 min later by an infusion of 5.4 mg/kg of body weight per hour for 23 hours

Summary

- Spinal immobilization can reduce the likelihood of neurological deterioration in patients with unstable c-spine injuries following trauma
- Immobilization of the entire spinal column is necessary in patients until a spinal cord/ column injury has been excluded or until the appropriate treatment has been initiated

Summary

- A combination of rigid cervical collar with supportive blocks on a rigid backboard with straps is effective at achieving safe, effective spinal immobilization for transport
- Spinal immobilization devices are effective but can result in patient morbidity. They should be used for safe extrication and transport, but should be removed as soon as definitive evaluation is accomplished or treatment initiated

Summary

- Methylprednisolone therapy for acute spinal cord injury is controversial with only benefit when administered within 8 hours of injury
- Current Methyprednisolone regimen:
  - Methylprednisolone bolus intravenous infusion of 30 mg/kg of body weight over 15 min within 8 hours of acute closed spinal cord injury
  - Followed 45 min later by an infusion of 5.4 mg/kg of body weight per hour for 23 hours
- Appropriate classification of SCI patients within ED to ensure prompt evaluation and treatment
- Communication between ED staff and residents is key to limiting errors and providing appropriate care

Questions?

PD-SELF

Erin Silversmith (Wikipedia)

References

- Baron, B., Thomas, S. Spinal Cord Injuries, in *Emergency Medicine: A Comprehensive Guide*. Tintinalli, Editor. 2004, McGraw-Hill. p. 1569-1583.
- American College of Surgeons. Spine and Spinal Cord Trauma, *in Advanced Trauma Life Support for Doctors 7th edition*. 2004. p. 177-204.
- Lin, M., Mahadevan, S. Spine Trauma and Spinal Cord Injuries, *in Emergency Medicine*. Adams, Editor. 2008, Saunders Elsevier. P. 765-783