Cervical Spine Injuries
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Objectives
At the conclusion of this lecture the participant should be able to:

- Explain basic spinal cord anatomy and its function
- List the risk factors for cervical spine (c-spine) injury
- Recognize who which patients should have cervical spine protection
- Explain the factors that make a trauma patient at low risk for cervical spine injury
- Identify the basic in hospital evaluation and treatment of someone suspected of spinal injury

Because it Saves and Improves Lives

- Any pre-hospital care provider soon realizes after putting several dozen people in a c-collar and long board that the majority of people immobilized will be without injury. As an EMT you may become tired of hospital staff second-guessing the immobilization of certain patients. This lecture is designed to review spinal injury basics and explore the impact that cervical spine injuries have. Also we will cover research covering the possibility of pre-hospital clearance of cervical spines. Hopefully, this will reinforce that the effort given to protect all those cervical spines truly protects patients and saves lives.

Effect of not protecting a potential cervical spine injury

- Cost of medical treatment: Annual estimated cost of spinal cord injury is over 5 billion dollars
- Cost of disability and social security
- Loss of productivity to society
- Loss of able bodied family member
- Higher death rates from complications, infections, and surgery for spinal injured patients
- Financial and Anxiety issues regarding malpractice lawsuits

Negative aspects of implementing cervical spine protection for those suspected of injury

- Majority of patients placed on backboard and c-collar will have no injury
- Medical cost of pre-hospital
- Medical screening (physician fees as well as x-rays)
- Discomfort of the backboard to someone who is already in pain
- Increased risk of back injury to pre-hospital providers
- Diverting resources away from the truly injured or ill
- Increase cost of insurance from increasing premiums to cover hospital treatment

References

1. ED Lerner EB, Moscati R: Duration of Patient Immobilization in the Emergency Department: *American Journal of Emergency Medicine:* 2000:1:18:
2. Cordell WH, Ayers JA, Olinger ML, et al: Duration of immobilization and pain experienced on rigid spine boards. *Annals of Emergency Medicine*: 1996;27:147-148

Epidemiology:

- There are over 13,000 new spinal cord injuries per year.
- There are more than 200,000 patients with spinal injury in the U.S.
- The average cervical spine (c-spine) trauma victim is in their mid-twenties
- Males are involved more often than females.
- Motor Vehicles are responsible for 41 percent of acute spinal injuries
- Falls account for 15 percent of acute cervical spine injuries
- Sports account for five percent of those injured

References

1. Mahoney BD: Spinal Injuries, In Tintinalli JE, Krome RL, Ruiz E *: Emergency Medicine A Comprehensive Study Guide*. New York, McGraw-Hill, Inc, 1992, p 922
2. Lowery DW, Wald MM:. Epidemiology of cervical spine injury victims*: Annals of Emergency Medicine* 2001:38:1 •
3. *Spinal Cord Injury Statistics*; Birmingham, AL: National Spinal Cord Injury Association Resource Center; 1999.

What is the overall outlook for someone who suffers a c-spine injury?

- Maynard performed a clinical study to answer this question
- This study included 103 patients with spinal cord injury who were not mentally affected
- None of the patients that had complete injury at 72 hours were walking at one year
- Those patients who had partial function at 72 hours showed better results
- Of patients with some sensory (muscle) function at 72 hours post injury, 47 percent were walking in a year
- Patients with incomplete motor (muscle) function, 87 percent were walking at a year
- In short, aggressive treatment and c-spine precautions in the field and hospital can improve outcomes, even if the spinal cord has already been partially injured

Anatomy

- The human spine has 33 bony vertebrae
- 7 Cervical Vertebrae (C-spine)
- 12 Thoracic Vertebrae (T-Spine)
- 5 Lumbar Vertebrae (L-spine)
- 5 Sacral Vertebrae (fused
- 1 Coccyx
- The spongy, flexible, disks cushion the vertebrae from each other
- These vertebrae provide the basic support structure for our body
- Importantly, they protect the delicate spinal cord from injury
- The thoracic spine obtains its strength and stability from it attachments to the chest
- The lumbar and sacral vertebrae gain stability and strength by connections to the pelvis
- The cervical spine also has connections to the chest but much less than the thoracic

- In addition the cervical vertebrae must bear the weight of the skull and its contents
- In a trauma, the weight and force on the c-spine is sometimes likened to an orange on a toothpick

Cervical Vertebrae Anatomy

- There are 7 cervical vertebrae
- The first vertebrae directly under the head is referred to as C-1(C for cervical)
- C-1 is also referred to as the atlas.
- It was named after the Greek god Atlas who was punished by supporting the weight of the world on his shoulders
- Part of the second vertebrae protrudes into the c-1 to form a sort of ball and socket joint
- This becomes important because this portion of c-2 that sticks up into c-1 provides stability for the neck-head apparatus, but is also prone to trauma
- Numerous Ligaments (tough connecting fibers) attach one vertebra to the next
- This provide stability and helps to maintain normal straight alignment
- Tendons from the neck and back muscles exert force to help maintain an erect and stable posture
- Tendons attach to various points of the neck and back to rotate, flex and extend the spine
- For every day running, jumping, and falling, the vertebrae with it's fibrous attachments serve as an excellent protection to the spinal cord inside

Anatomy of the spinal cord

- The brain sends and receives signals to and from the body through nerves
- The nerves run to and from the body along the spinal cord
- The nerves come together as the spinal cord and travel to the brain
- Thus the spinal cord serves to carry sensory and motor (muscle) information to and from the brain
- The nervous system can be divided into the central and the peripheral nervous system
- The central nervous system includes the brain and spinal cord
- The peripheral nervous system are all the nerves outside the spine

Different areas of spinal cord injury

- The portion of the spinal cord that is closest to the head is critical for life
- This area is responsible for controlling some of the muscles for breathing
- Injuries around cervical spine 3(C-3) will lead to loss of function to the diaphragm
- The heart would still beat
- The brain would still try to send signals to the diaphragm to contract and breath but these signals would not continue past the damaged area of the spinal cord
- The nerves that control the muscles and sensation to the upper extremities only run through the cervical portion of the spine
- Nerves that control the lower extremities and pelvis run from the brain all the way to the lower back (lumbar and sacral) areas of the spine

Damage to an area of the spinal cord will affect that level of the cord and whatever is below it

For example:

- Complete damage to the spine at the cervical level would cause paralysis and loss of sensation to the arms, torso, and legs
- If the injury were high enough, like the cervical spine level 3,4 there would be paralysis of the diaphragm and loss of the ability to breathe normally. (Some of the muscles in the neck would not be affected, and some patient's can use accessory muscles to ventilate minimally)
- Complete damage to any area below the cervical spine would not affect the upper extremities, but would cause lower body paralysis and numbness

Mechanism of spinal injury

- The spinal cord is very delicate
- In 1985 Allen demonstrated the spinal cord was extremely sensitive to damage
- This he showed by dropping a 10-gram weight from 10 centimeters onto exposed spinal cord of a live animal
- Initial impact caused immediate paraplegia without any associated visible or microscopic cord damage
- Several hours later the cord developed a bloody, damaged area that progressed to cell death
- The cell death was caused by blood entering the damaged part of the cord
- The blood carries inflammatory molecules that cause further injury to the spinal cord
- Researchers have investigated many drugs and treatments to stop the inflammation process
- Such drugs include steroids, diuretics, narcan, hyperbaric oxygen and hypothermia
- The only intervention that has shown any promise is been high dose steroids
- Given the delicate nature of the spinal cord, it is amazing that spinal cord injuries don't occur more often

Injury to the spinal cord

Some Interesting Clinical Points

- The anterior (front) half of the cord contains the nerves that control motor function and pain
- The posterior portion of the cord controls sense of touch and limb motion
- Thus blunt or penetrating injury to the front half of the cord will result in weakness and loss of pain below the area of injury
- This is called Anterior Spinal Cord Syndrome
- The nerves that control the upper extremities are located in the middle of the spinal cord
- The nerves that control the lower extremities are located on the outside of the cord
- In compression type injuries the entire cord is squeezed
- The middle of the cord is prone to less perfusion when compressed
- The area of low blood flow causes damage to the nerves in the center of the cord
- Thus if you are evaluating a patient with greater weakness in the hands than legs this patient probably has what is call Central Cord Syndrome
- Cord injury is usually caused when there is damage to the stabilizing ligaments
- A damaged cervical ligament allows the cervical spine to slide and compress the cord

Spinal shock

- Spinal shock is a syndrome that occurs after that the spinal cord sustains an injury
- It usually occurs within 24 hours of the injury
- Spinal shock is temporary lasting from hours to weeks.
- The patient initially develops a flaccid (no muscle tone) quadriplegia
- The prognosis after spinal shock is not good
- Those who recover are expected to remain quadriplegic

Neurogenic Shock

- Patients with spinal injury may develop neurogenic shock
- Neurogenic shock occurs when the nerves that control blood pressure are damaged
- The sympathetic nervous system is responsible for innervating and constricting arteries. Loss of sympathetic tone causes vasodilatation, hypotension and shock.
- Neurogenic Shock can be profound and not easily remedied by IV fluids

References

1. Mahoney BD: Spinal Injuries, Tintinalli's Emergency Medicine A Comprehensive Study Guide. New York, McGraw-Hill, Inc, 1999, p 922

Spinal Injuries and children

- Regarding the c-spine there are several key differences between children and adults
- Fortunately C-spine injuries are uncommon in children
- They consist of only 5% of the total population of c-spine injuries
- Children's heads are disproportionately larger than adults
- This means for any given trauma, the neck is subjected to greater force than an adult
- The child's disproportionately large head also causes misalignment when a child is placed in a c-collar
- The relatively large size of a child's head flexes the neck forward once a child is placed on a firm surface such as a backboard
- This position can be hazardous because it forces the vertebrae out of the desired "neutral position" where all of the vertebral bones are aligned
- To maintain a child's head in neutral position, it is necessary to place a folded towel underneath the shoulder blades (scapulas)
- These changes aren't significant after the age of **six**

SCIWORA

A person does not have to fracture a vertebra or disrupt ligamentous attachments to suffer spinal cord injury

- There is a syndrome call SCIWORA (Spinal Cord Injury Without Radiological Abnormality)
- Patients with SCIWORA may have either a sensory or motor deficit
- In 2001 RL Brown completed research on 103 consecutive c-spine injuries in children
- 38% of patients had SCIWORA
- Most injuries were due to automobile accidents

- The next most common cause was football

Clearing the Cervical Spine on clinical grounds (Physical Exam and History alone)

- This is a hot topic for investigation
- Very few people who are treated as possibly having a cervical spine injury actually have one
- The consequences of not immobilizing a patient with an actual c-spine injury is severe
- The goal is to minimize the amount of unnecessary immobilization without missing any c-spine injuries
- There are many protocols in the emergency medicine literature regarding physician clearance of the cervical spine in the emergency room
- **Can a policy or protocol be created to clear patients unlikely to have a cervical spine injury in the pre-hospital setting?**
- First some background on the research looking into clearing the c-spine clinically

References

1. Chan D, Goldberg TR, Tascome A, et al: The effect of spinal immobilization on healthy volunteers. *Annals Emergency Medicine* 1994;23:48-51

One of the most popular and effective studies that looked at this topic was called the NEXUS

- NEXUS stands for National Emergency X-radiography Utilization Study
- NEXUS was an investigation of pure clinical evaluation to determine which trauma patient's c-spine could be cleared safely without x-rays.
- The goal was to minimize unnecessary time, cost, and discomfort to the patient
- This study used emergency medicine physicians to evaluate the injured patients
- Their results were as follows

Low risk patients were those who:

- Had normal mental status
- Had no tenderness to palpation along the midline (bony parts) of their cervical spine
- Did not have neurological deficits on examination or history
- Were not affected by substance that might impair judgment (alcohol, drugs, morphine)
- Had no other injury, which might distract them from recognizing neck pain or tenderness

Should Pre-hospital providers clear cervical spines?

Arguments for it are:

- Many patients are brought in on board and collar by current criteria that end up having no c-spine injury
- This takes up tremendous resources

- Emergency Medical Services already perform more complicated evaluation and treatment than clearing cervical collars
- Prolonged time on the backboard is uncomfortable and can actually cause problems to the patient

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1. ED Lerner EB, Moscati R Duration of Patient Immobilization in the Emergency Room: *American Journal of Emergency Medicine:* 2000:1:18:
2. Cordell WH, Ayers JA, Olinger ML, et al: Duration of immobilization and pain experienced on rigid spine boards. *Annals of Emergency Medicine:* 1996;27:147-148
3. Lerner EB, Billittier AJ, Moscati R: Effects of neutral positioning with and without padding on spinal immobilization. *Prehospital Emergency Care*:1998;2:112-116

Arguments against pre-hospital clearance of backboards are

- The spinal cord is extremely sensitive and does not heal well after damage, and as such should be cleared by personnel with more training
- "The current system seems to work"
- Spinal cord injuries are an area filled with law suits
- It revenue away from hospitals

In 2001 Stroh set out to answer the question "Is it safe to allow EMS to clear cervical spines in the field?"

- Stroh Performed a chart review assessing effectiveness pre-hospital clearance of c-spines
- Undertook a chart review of 861 patients
- They correctly immobilized 99% of 504 patients with significant c-spine injuries
- They concluded, "Selective immobilization may be safely applied in the out-of hospital setting"

References

1. Stroh, G: Can an out-of-hospital cervical spine clearance protocol identify all patients with injuries? An argument for selective immobilization**:** *Annals of Emergency Medicine*
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Who is at Increased risk for cervical spine injuries?

- Elderly
- Calcium deposits in their ligaments make the connections between the spines stiff and more likely to snap than stretch or strain
- Low muscle tone to combat the tremendous forces distributed during a blunt traumatic event

- Patients with who are on long term oral steroids for treatment of inflammatory disorders such as asthma, autoimmune diseases such as lupus, or rheumatoid arthritis. Steroids cause osteoporosis (weakening and thinning of the bone structure)
- Patients with rheumatoid arthritis. (an inflammatory disease where the body attacks its own joints) These patients are often on high dose steroids, an additional risk factor.
- Patients who have Downs syndrome

References

1. Spivak JM, Weiss MA, Cotler JM, et al. Cervical spine injuries in patients 65 and older. *Spine.* 1994; 19:2302-2306

What Type of trauma mechanisms are considered high risk for c-spine injuries?

- Pedestrian hit by automobile
- Fall from greater than twice the height or twenty feet
- Starring of the windshield in and auto accident
- Ejection of the patient from a moving vehicle during a collision
- Motorcycle accidents
- Diving accidents
- Any trauma that makes the patient unresponsive
- Any blunt trauma patient complaining of numbness, weakness or neck pain

References

1. Mahoney BD: Spinal Injuries*,* Tintinalli's Emergency Medicine A Comprehensive Study Guide: New York, McGraw-Hill, Inc, 1999, p 922
2. Hoffman JR, Schriger DL, Mower WR, et al. Low-risk criteria for cervical spine radiography in blunt trauma: a prospective study. *Annals of Emergency Medicine.* 1992; 12:1454-1460.

Pre-Hospital evaluation and treatment for the patient suspected of having c-spine injury
Key History Points

- Assess whether the patient is at high risk for c-spine injury given the criteria mentioned earlier
- Pedestrian hit by automobile
- Fall from greater than twice the height or twenty feet
- Starring of the windshield in and auto accident
- Ejection of the patient from a moving vehicle during a collision
- A trauma with a mechanism severe enough to break
- Motorcycle accidents
- Hanging from a height twice the height of the patient
- Diving accidents
- Any trauma that makes the patient unresponsive
- Any blunt trauma patient complaining of numbness, weakness or neck pain

- Anyone with these mechanisms should have a cervical collar
- All patients placed in a collar should be placed on a firm backboard as a cervical collar alone cannot immobilize C1&C2 effectively

References
1. Mahoney BD: Spinal Injuries, In Tintinalli JE, Krome RL, Ruiz E : Emergency Medicine A Comprehensive Study Guide. New York, McGraw-Hill, Inc, 1999, p 922

Past Medical History
- Extensive use of steroids
- Prior Spine injury or surgery
- Downs Syndrome
- Osteoporosis
- Rheumatoid or degenerative arthritis

Physical Exam
- As always the ABC's must be addressed first
- Specifically for the patient with a potential spinal cord injury:

A: Airway
- The airway may be compromised if there is an associated head injury with loss of consciousness. Spinal cord injuries by themselves do not, however, usually present with airway problems

B: Breathing
- Patients with a C-spine injury to C1-C4 may have damaged the nerves that signal the diaphragm to contract
- These patients may be awake with normal cardiac function, but unable to breathe
- Rapid and definitive airway intervention should occur (intubation if available or pulmonary resuscitation through provider protected mask to mouth or bag valve mask
- If intubating, the Miller (straight) blade provides the least movement of the cervical spine
- However, research has consistently shown that the most effective type of laryngoscope blade is the one in which the operator is most experienced and feels most comfortable

C: Circulation
- Patients with severe spinal cord injury may develop spinal shock.
- These patients will have warm, pink, and dry skin
- Spinal shock patients have low blood pressures, refractory to intravenous fluids therapy
- These patients also typically have a slow or normal heart rate despite low blood pressure

References
1. Gerling et al: Effects of cervical spine immobilization technique and laryngoscope blade selection on an unstable cervical spine. Annals of Emergency Medicine. 2000:36:4

Physical Exam Continued
General:
- Is the patient conscious and moving all four extremities spontaneously

- A walking and alert patient does not rule out the possibility of hidden c-spine injury, as only 39% of patients with cervical spine fractures will have associated neurological injury
- Assess the patient's overall mental status and ability to follow instructions

References
1. Augustine JJ: Spinal Trauma, In Campbell JE (ed): Basic Trauma Life Support for Paramedics and Advanced EMS Providers, Ed 3. 1998, p 153

Skin:
Inspect the body for injury
- The patient already in a collar and backboard will need to be log rolled to protect the spine in order to examine the back
- Palpate for tenderness or deformities along the entire length of the spine

Cardiac:
- Feel for pulses distally and check blood pressure to assess if the patient is hypotensive with a normal pulse, a sign of spinal shock

Respiratory:
- Assess the movement of patient's chest with breathing. Poor movement may indicate high cervical injury

Abdomen:
- Loss of abdominal muscle tone may signify a cervical injury

Pelvis:
- Loss of bladder or bowel function may be sign of loss of consciousness or indicate damage to either the upper or lower spinal cord (incontinence with normal upper extremity but weak lower extremity is probably a lower injury (thoracic, lumbar, sacral)

Neuromuscular:
- Check grip strength, and push against resistance to assess for upper motor weakness. Have patient lift legs at the hip and push and pull with their feet.
- 39% of patients with cervical spine fractures will have associated neurological injury and weakness or numbness
- For a brief sensory exam: Brush lightly across thumb and small finger as well as big and small toe.
- Most patients who have no complaints and have a normal neurological exam as described above have not sustained a spinal cord injury
- ***This does not mean that they do not have an unstable vertebral injury that, when moved, would cause spinal cord injury***

References
1. Augustine JJ: Spinal Trauma, In Campbell JE (ed): Basic Trauma Life Support for Paramedics and Advanced EMS Providers, Ed 3. 1998, p 153
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Once the patient arrives in the Emergency Room:

- Patients are triaged depending on the extent or suspicion of injury

- This decision is almost entirely based on the information pre-hospital providers acquire and provide the hospital staff
- If the patient has suspected spinal cord injury or other life or limb threatening injuries, they should be placed inside a dedicated trauma room
- Once in the trauma room a more complete evaluation is performed

Who can be cleared from the cervical collar?

- Low mechanism
- Alert GCS (Glasgow Coma Scale) 14-15
- No distracting injuries
- No masking conditions alcohol consumption, hypoglycemia
- No tenderness to cervical spine

References

1. Hoffman JR, Schriger DL, Mower WR, et al. Low-risk criteria for cervical spine radiography in blunt trauma: a prospective study. Annual Emergency Medicine 1992;12:1454-1460.
2. Givens TG, Polley KA, Smith GF, et al. Pediatric cervical spine injury: a three-year experience. *J Trauma.* 1996;41:310-314.

Assessment of a presumed spinal cord injury

- Patient remains on board and collar
- Full set of vitals performed to rule out spinal shock
- Strength, sensory, and reflexes are tested to isolate suspected area of spinal cord injury
- The patient is log rolled, keeping vertebrae in alignment, and the spine is inspected and palpated to feel for any deformity or sign of bony injury
- A rectal exam is done to check for loss of rectal sphincter tone
- Loss of rectal sphincter tone is a sign of lower spinal cord injury
- In males the penis is also examined looking for priapism (prolonged, often painful erection), which can be a sign of spinal cord injury
- After the patient has been examined a routine x-ray of the cervical spine is taken
- Lumbar and thoracic vertebrae are difficult to fracture this is because they have many muscular, tendonous, and ligamental attachments that supports the vertebrae
- If the patient has any neurological defect several steps can be taken
- The patient is started on a very high dose steroid regimen (Decadron)
- Decadron theoretically acts to protect the spinal cord from further injury by decreasing the amount of inflammatory damage caused after the trauma
- The research supporting steroid use in spinal cord injury is not strong but the benefit is potentially very great and the risks very small
- If the patient has an unstable neck fracture, a neurosurgeon will need to surgically stabilize the broken vertebra

References

1. Mahoney BD: Spinal Injuries: *Tintinalli's* Emergency Medicine A Comprehensive Study Guide. New York, McGraw-Hill, Inc, 1999, p 922

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