

# The Assessment & Management of Spine & Spinal Cord Injuries in the Field:

Where We Started,  
Where We are Now,  
& Why



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# Brief History of Prehospital Spine Management

- ◆ 1966 ~ Department of Transportation (DOT) established due to high number of traffic deaths.
- ◆ 1972 ~ First Physician residency in Emergency Medicine (25 by 1975).

- Minimal pre-hospital spinal immobilization prior to 1973; no nationally accepted criteria or EMS system.

- ◆ 1973 ~ EMS Act provided funding for 300+ national EMS systems and supplied a national curriculum, including spine immobilization.

- Stabilize patient's spine—prevent movement—during Basic Life Support (BLS) until the mechanism of injury (MOI) was established.
- If the MOI was major trauma or unknown, the patient's spine was fully immobilized based on the premise that movement of an unstable spine injury will result in a spinal cord injury *and* that external spinal immobilization will prevent that movement *and* full immobilization was not harmful.

- ◆ 1983 ~ Wilderness Medical Society (WMS) founded
- ◆ 1984 ~ National Association of EMS Physicians (NAEMSP) founded

- ◆ 1984 ~ First formal WFR class taught; NOLS, WMA, SOLO, & WMS had their own FSA predating NEXUS (2000), CCR (2001), New Hampshire State Protocols, (Hubbell 1993), NEMSP (Goth 1993), State of ME (1990) & WMS (2013).

- Stabilize patient's spine during BLS—no spine movement ± cervical collar—until the MOI was established.
- Focused Spine Assessment (FSA).
- *Full spine immobilization if patient failed the FSA.*

- ◆ 1998 ~ Professor Mark Hauswald, MD, Department of Emergency Medicine, University of New Mexico released a five-year retrospective study comparing trauma patients in Malaysia with those seen in a US hospital. *None* of the 120 patients seen at the University of Malaya were immobilized during transport while *all* 334 patients seen at the University of New Mexico were. *The study showed a significantly higher rate of neurologic injury in the immobilized group.*
- ◆ 2012 ~ Hauswald released an article on the biomechanics and pathophysiology of spinal injuries. In his article he asserts that most spinal injuries are biomechanically stable, that the majority of those few patients with unstable spinal injuries will already have spinal cord damage as a result of the forces imparted during the traumatic event, and that pre-hospital immobilization will not affect either patient's outcome.
- ◆ 1998-present ~ International research on pre-hospital spine management techniques.

# So, what do we know now?

(Or think we know. Research is ongoing and data is still coming in.)

# Litter Evacuations

- ◆ Often dangerous for the patient.
- ◆ May be dangerous for rescuers.
- ◆ Expensive.



# Full Spinal Immobilization

- ◆ Requires a litter evacuation.
- ◆ Delays transport.
- ◆ May cause a raise in increased ICP and potential separation of cervical vertebrae when using a rigid cervical collar.
- ◆ May cause respiratory compromise in some patients due to positioning, chest straps, and/or rigid cervical collars.
- ◆ May cause pain.
- ◆ May cause pressure sores if the litter is not extremely well-padded.



# Current Research also Indicates

- ◆ A *very low* percentage of awake, alert, reliable, and ambulatory patients have an unstable spine or cord injury.
- ◆ Neurologic deficit—motor or sensory impairment not attributable to an extremity injury—indicates a potential spinal cord injury.
- ◆ Voluntary spine movement in awake patients within the patient's normal range of motion will not exacerbate the injury (or cause cord damage).
- ◆ Voice-responsive, pain-responsive, and unresponsive patient's spinal cords are best protected during an evacuation using a full-body vacuum splint. If a vacuum splint is unavailable, use thick, soft materials for padding under the patient and around their head, neck, and body to support their spine and minimize energy deposition to injured tissues during the evacuation.



# Relevant Questions

1. What are effective Basic Life Support (BLS) strategies for protecting a patient's spine and spinal cord in a remote or wilderness environment when the Mechanism of Injury (MOI) is major trauma or unknown?
2. What are the components of an effective Focused Spine Assessment? Is one protocol better than another?
3. What are the strategies for protecting a patient's spinal cord when the patient fails the Focused Spine Assessment (FSA)?

# Basic Life Support Spine Management

- ◆ Ask patients to remain still as you check and treat for severe bleeding during your primary survey.
- ◆ Do not attempt to hold a patient's head or restrain them if they are anxious or combative.
- ◆ Rigid cervical collars are potentially harmful.
- ◆ Attempt to rule out a potential spine injury using a recognized focus spine assessment protocol after completing your secondary survey.

# Apparent Discrepancies

- ◆ Some wilderness medicine providers and EMS agencies still advocate manually supporting patient's heads during BLS.

- Slightly delays transport.

- ◆ Some EMS agencies continue to use rigid C-collars.

- Slightly delays transport. May cause cervical distraction on application and increased ICP and pressure sores in long term.

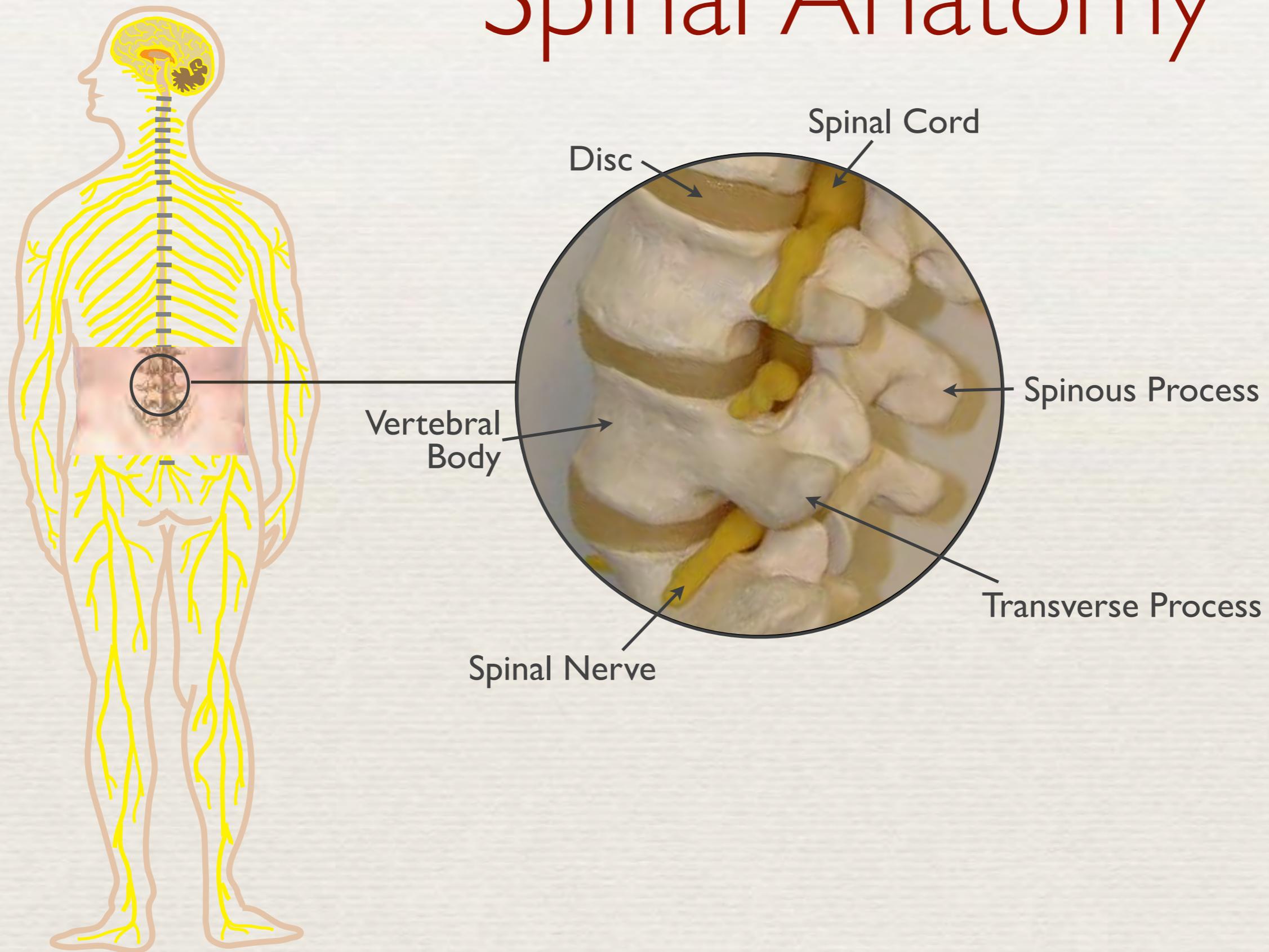
- ◆ Some EMS agencies continue to immobilize and transport patients on backboards.

- Delays transport. Will cause unwarranted discomfort and may restrict breathing; may cause pressure sores over time.

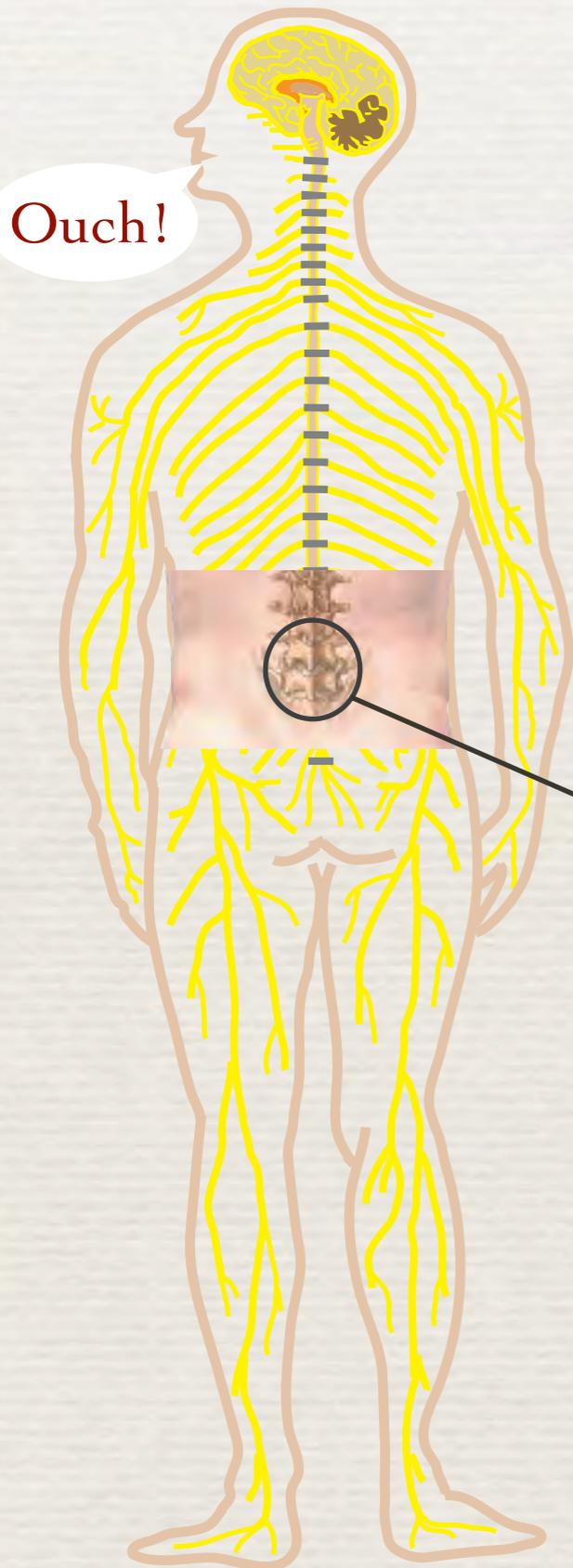
## Why?

- Some organizations are waiting for more data; some organizations are simply bureaucratic and slow to change.

# Spinal Anatomy



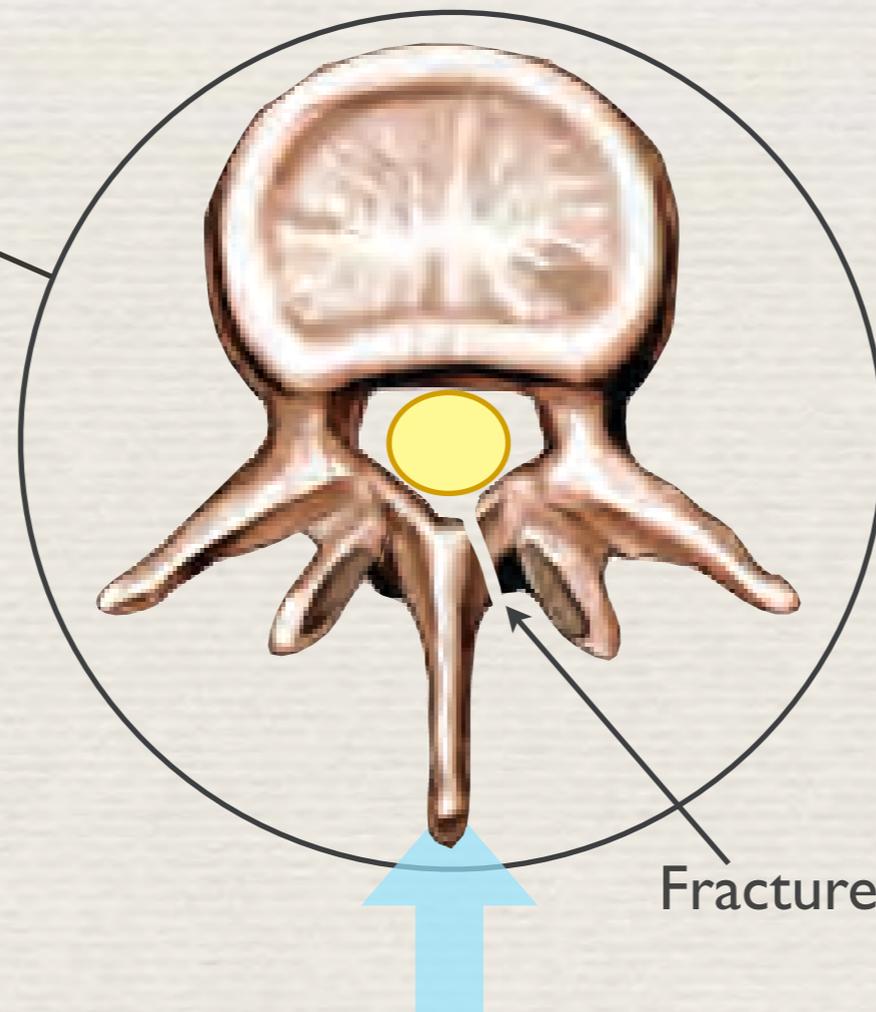
# Spinal Fractures



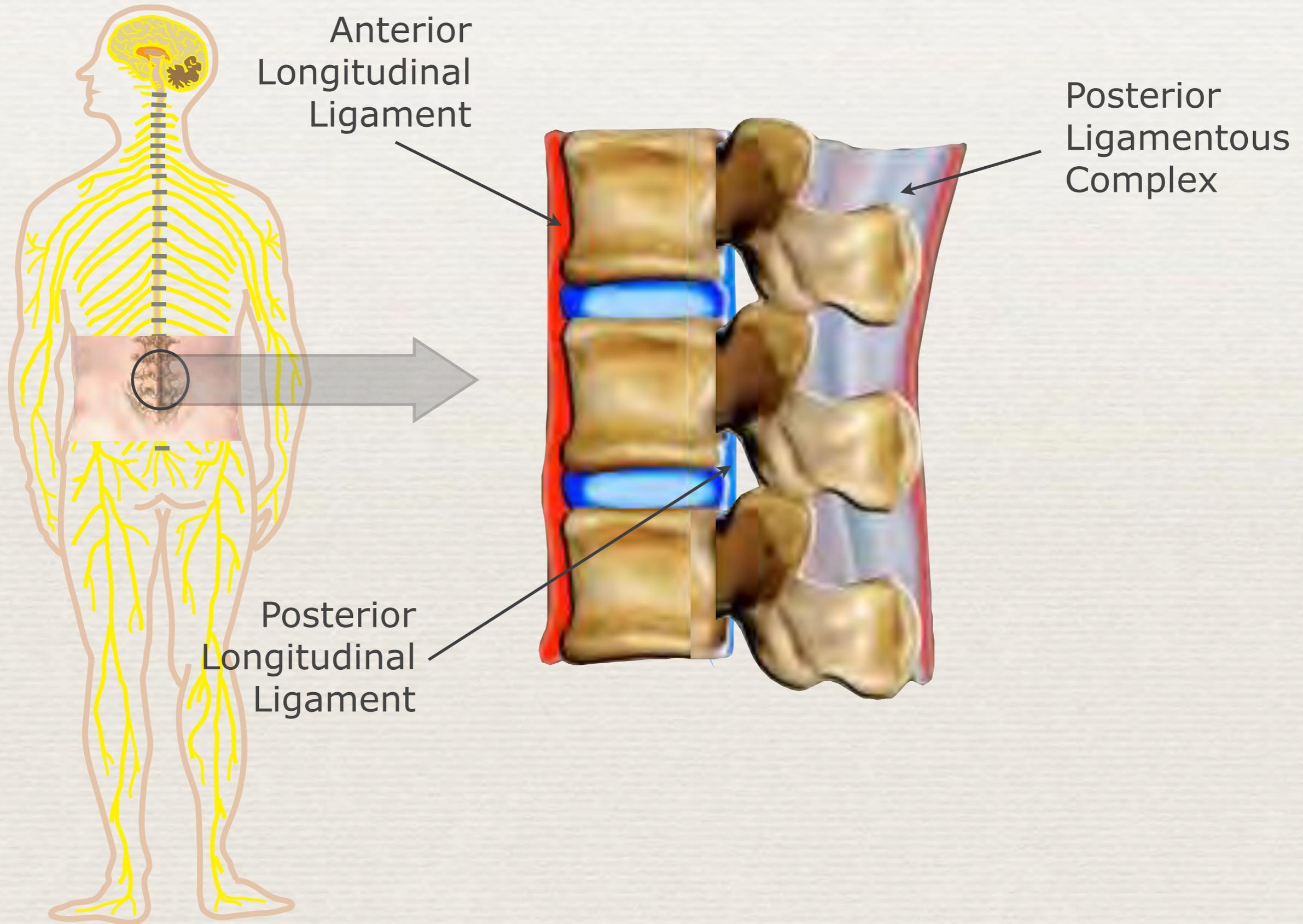
- ◆ Vertebrae are essentially boney circles that surround and protect the spinal cord.
- ◆ Vertebrae, like all bones, are surrounded with a highly enervated stuff sack.
- ◆ Spinal nerves originating in the lower cervical spine and upper thoracic spine enervate the hands.
- ◆ Spinal nerves originating in the lower lumbar spine and sacrum enervate the feet.

## Vertebral Fx

- ◆ Patients with a significant fracture anywhere in the boney inner circle will present with spine pain.
- ◆ Most fractures are tender when pressure is exerted on the spinous process.
- ◆ Paraspinal tenderness may also indicate a fracture.
- ◆ Not all vertebral fractures are unstable.



# Spinal Ligamentous Injuries



# Spinal Ligamentous Injuries

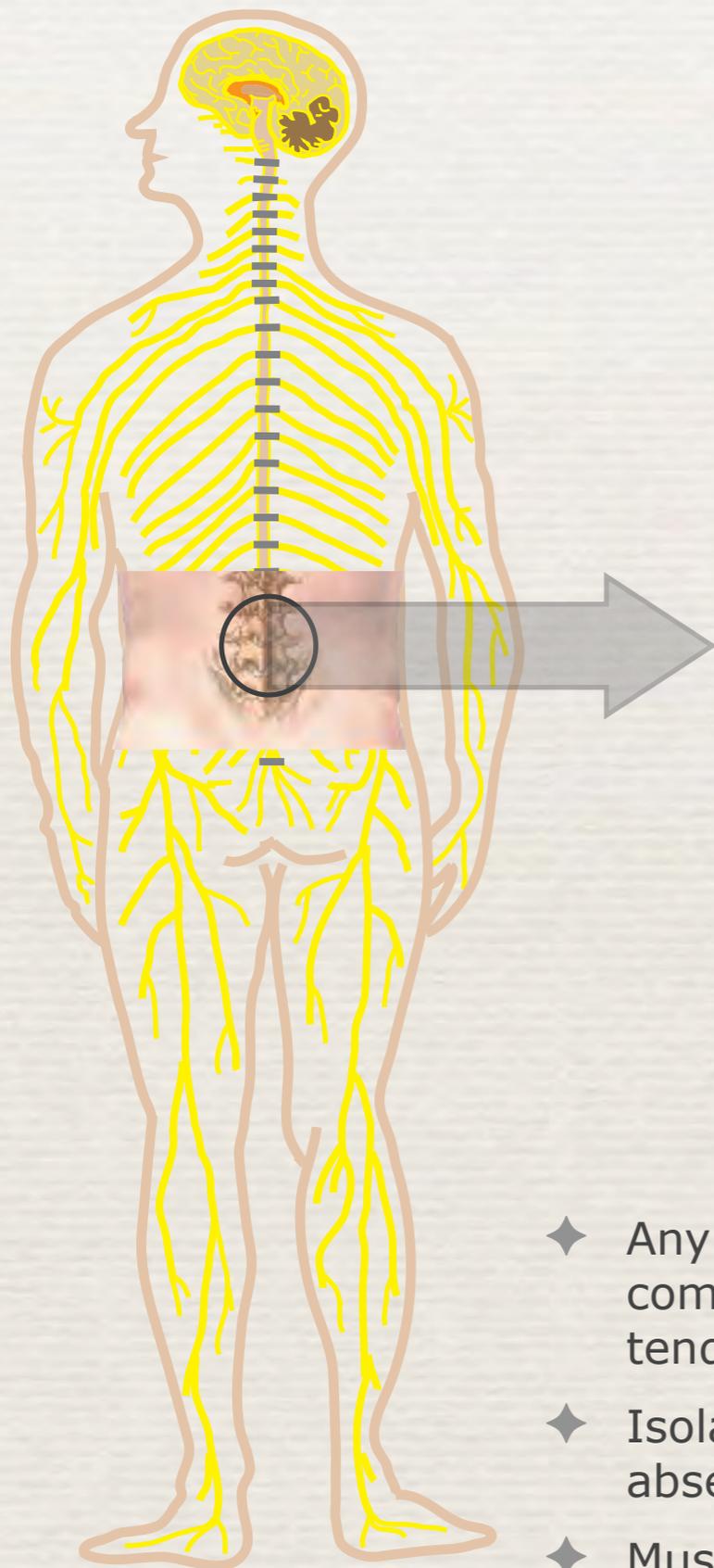
Anterior Column

Middle Column

Posterior Column

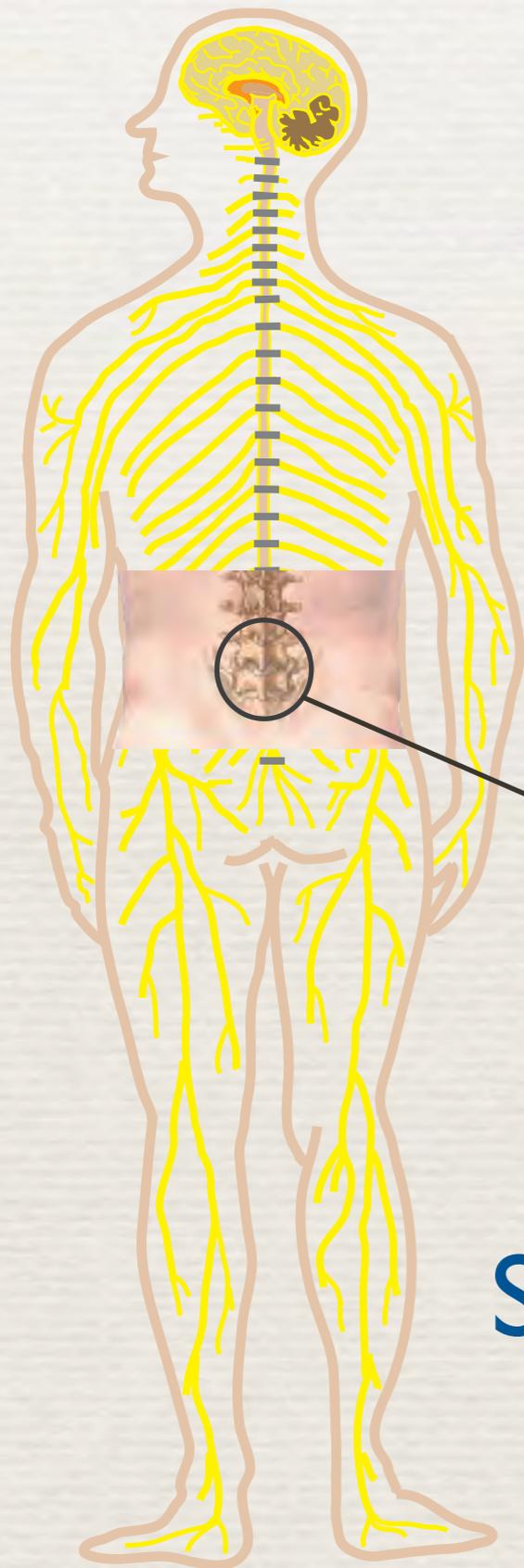


Radiologists conceptually divide the spine into three columns for assessment purposes.



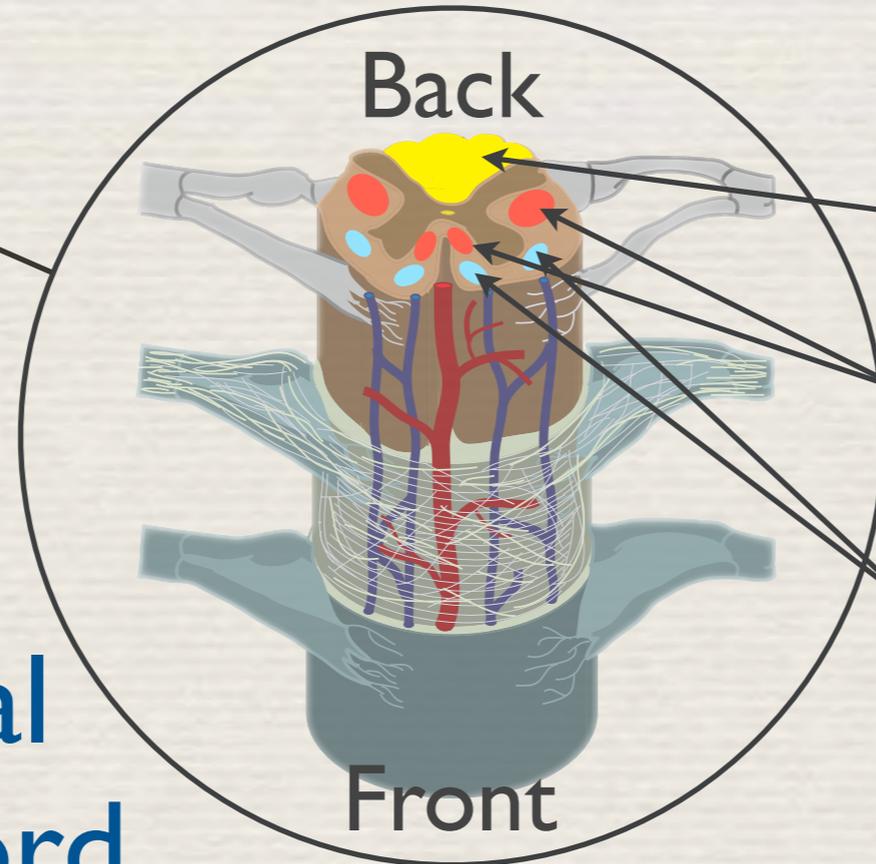
- ◆ Any injury that affects the posterior column or any two columns in combination has potential to be unstable and will present with pain and tenderness.
- ◆ Isolated ligamentous injuries also have potential to be unstable even in the absence of fractures and will also present with pain and tenderness.
- ◆ Muscle strains and sprains may also present with pain.

# Spinal Cord Anatomy



- ◆ The Spinal Cord carries information to and from the brain via electrochemical signals.
- ◆ Sensory tracts on the sides and front of the cord carry incoming signals for pin-prick pain, temperature, deep pressure, and coarse touch.
- ◆ Sensory tracts on the back of the cord carry incoming signals for light touch and joint proprioception.
- ◆ Motor tracts on the side and front of the cord carry out-going commands to their respective muscles.

**Spinal  
Cord**

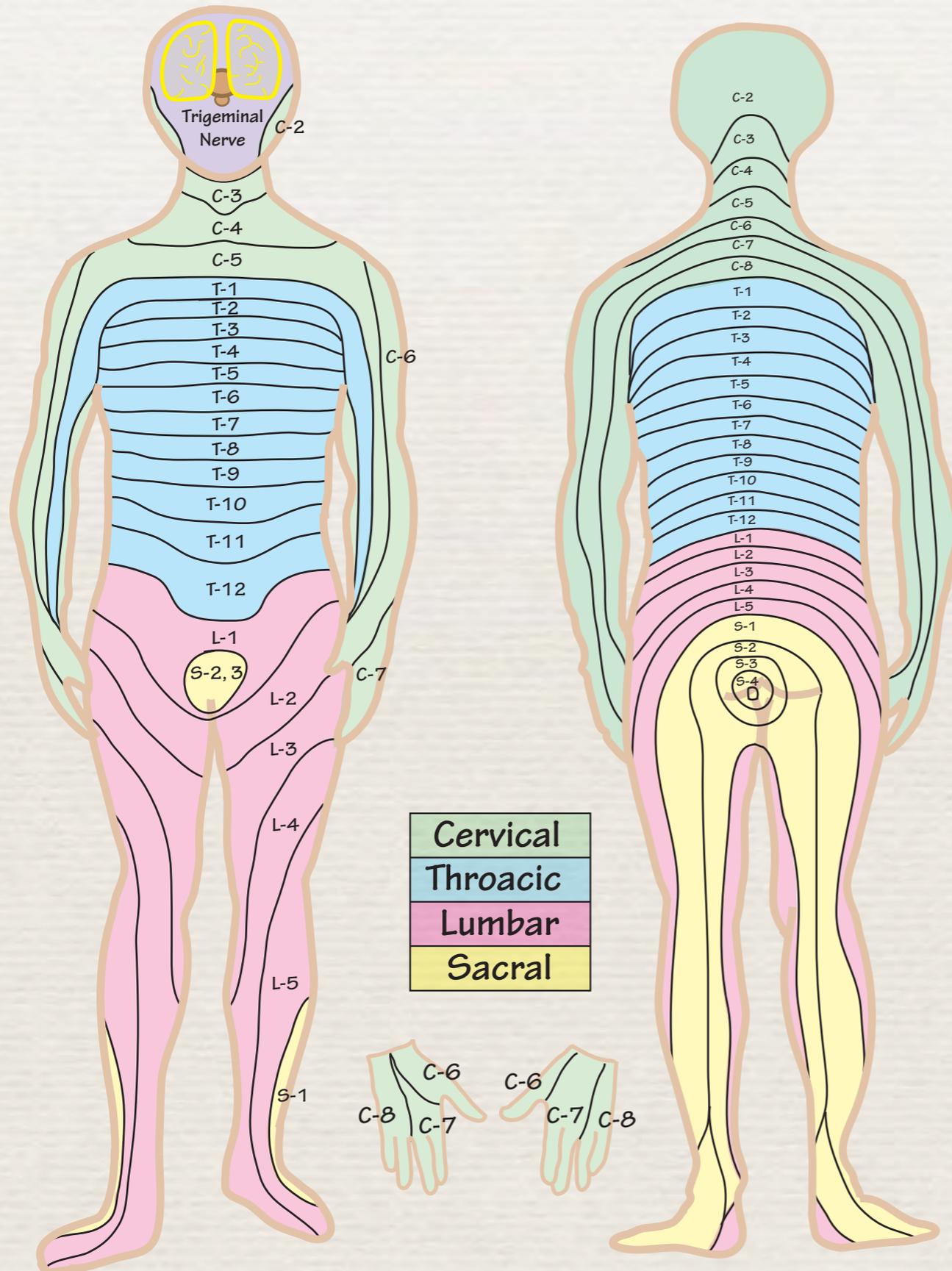


Incoming sensations for light touch & joint proprioception

Out-going motor commands to muscles

Incoming sensations for pin-prick pain, temperature, deep pressure & coarse touch

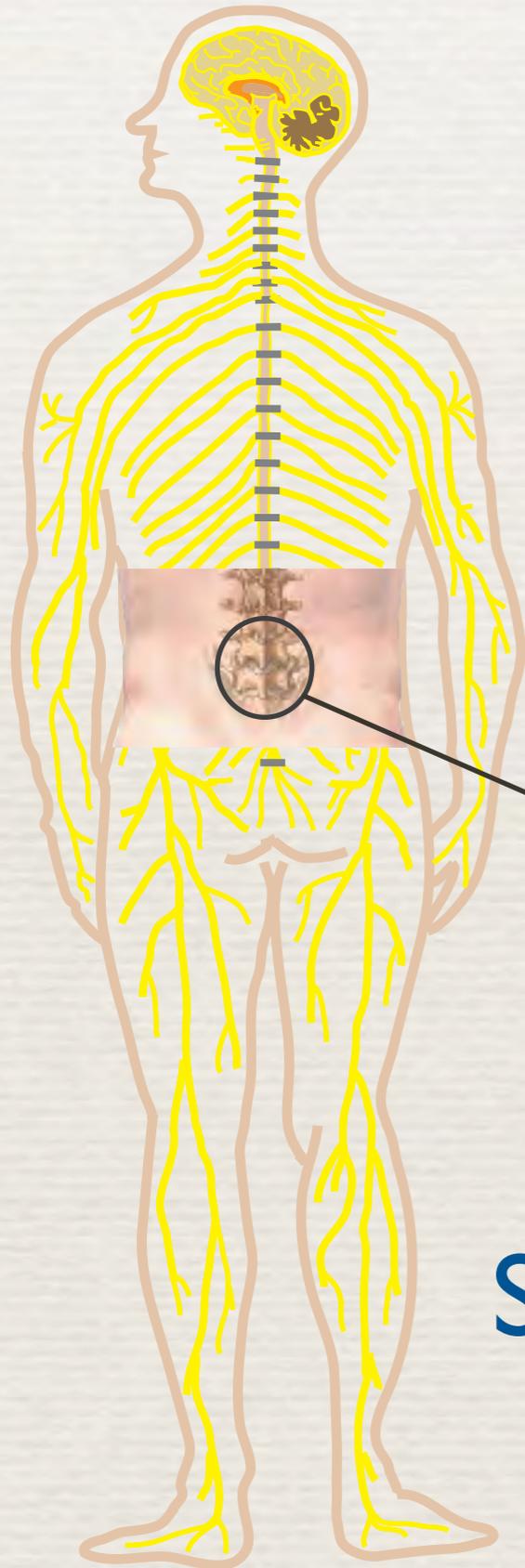
# Dermatomes



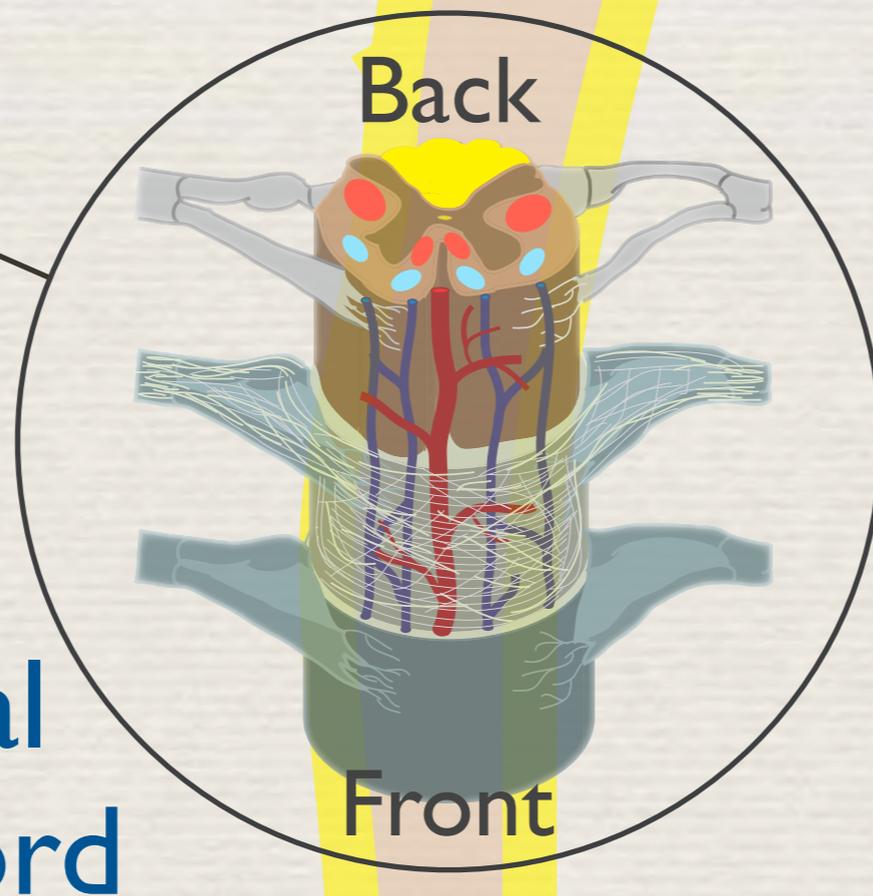
- ◆ There is one spinal nerve for each vertebrae and one for the head: cervical 1-8, thoracic 1-12, lumbar 1-5, and sacrum 1-5.
- ◆ Each spinal nerve has been traced to a specific region of the skin and mapped. The area of skin serviced by a spinal nerve is called a dermatome. Note that there is overlap between adjacent dermatomes.
- ◆ The sensory exam in the FSA consists of two parts and is based, in part, on dermatomes.
- ◆ C-7 and C-8 nerve roots service the back of the hands.
- ◆ L-5 and S-1 nerve roots service the front of the lower leg and the top of the foot.

# Spinal Cord Damage

(neurological deficit)



- ◆ If completely cut by a traumatic MOI the patient will not be able to feel or move below the damaged level.
- ◆ Partial damage is rare but possible and may be detected thorough motor and sensory exams on the patient's hands and feet during the FSA.
- ◆ If all sensory tracts are intact, a patient will be able to distinguish between a light touch and a pin-prick.



Spinal  
Cord

- ◆ If all motor tracts are intact a patient will demonstrate equal strength on both right and left sides during the motor exams.
- ◆ A partially damaged (or compressed) spinal cord or spinal nerve may present with electric, tingling, or shooting pain down one or both arms *or* legs.
- ◆ It is unusual to have motor loss without sensory loss.

# Focused Spine Assessment

- ◆ The 2000 National Emergency X-Radiography Utilization Study (NEXUS) and the 2001 Canadian C-spine Rule (CCR) produced the two most widely used algorithms used in EDs to identify patients who do not require imaging.
- ◆ Use of the NEXUS and CCR criteria for the field clearance of potentially unstable spine injuries is both safe and effective.
- ◆ Meta-analysis on clearance of the asymptomatic cervical spine showed the NEXUS & CCR negative predictive value is roughly 99%; their positive predictive value is roughly 4%. *The overwhelming majority (96%) of patients who fail either exam do not have an unstable spine injury.*
- ◆ Most wilderness medicine providers teach a focused spine assessment based on the NEXUS algorithm and modified to include spine pain and applies to the entire spine. (Specific motor & sensory exams may vary.)
- ◆ State of Maine protocol is also based on the NEXUS algorithm and includes spine pain and paraspinal tenderness.
- ◆ In 2013 the Wilderness Medical Society proposed a algorithm using criteria from both the NEXUS and CCR that subjectively reduced the threshold for pain and adds range of motion tests for the cervical and lumbar spine.

# Canadian C-spine Rule

Any HIGH risk factors?  
Any of the following:

- Age  $\geq$  65 years
- Dangerous Mechanism\*
- Paresthesias in extremities

NO

YES

Any LOW risk factors?  
Any of the following:

- Simple rear-end MVC\*\*
- Ambulatory at any time
- Delayed onset of neck pain
- Absence of midline C-spine tenderness

YES

NO

NO

Able to ROTATE neck actively?  
• 45° left & right

YES

No Spine Injury

Cannot apply CCR if:

- Patient is NOT awake, alert, & reliable
- Unstable vital signs
- < 16 years
- Acute paralysis
- Known vertebral disease
- Previous C-spine surgery

Possible Spine Injury  
• Evacuate for imaging

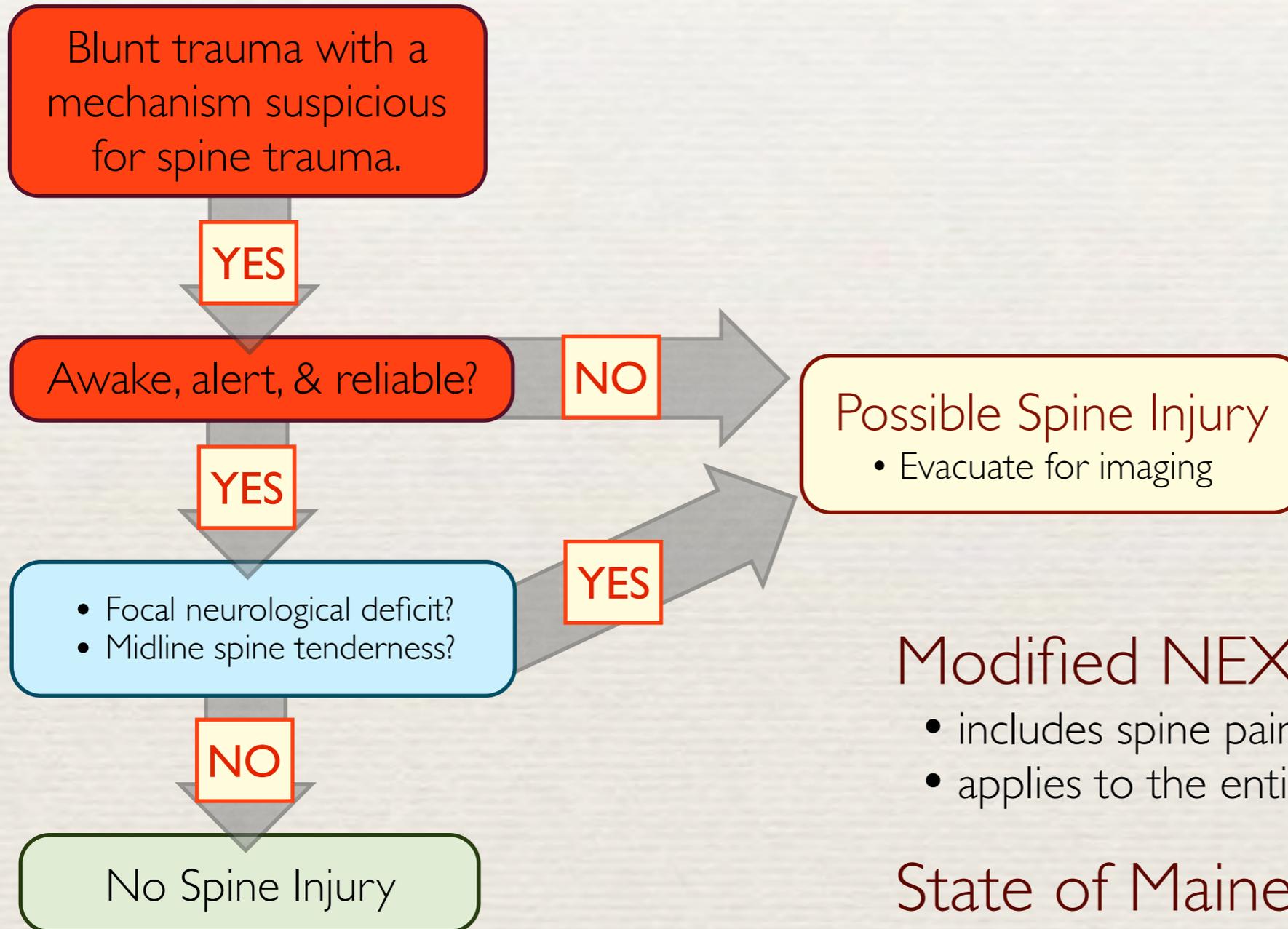
\*Dangerous Mechanism

- Fall from elevation  $\geq$  3 feet or 5 stairs
- Axial load to head
- MVC high speed ( $>$  100 km/hr) rollover, ejection
- Motorized recreational vehicles
- Bicycle struck or collision

\*\*Simple rear-end MVC excludes:

- Pushed into oncoming traffic
- Hit by bus/large truck
- Rollover
- Hit by high speed vehicle

# NEXUS



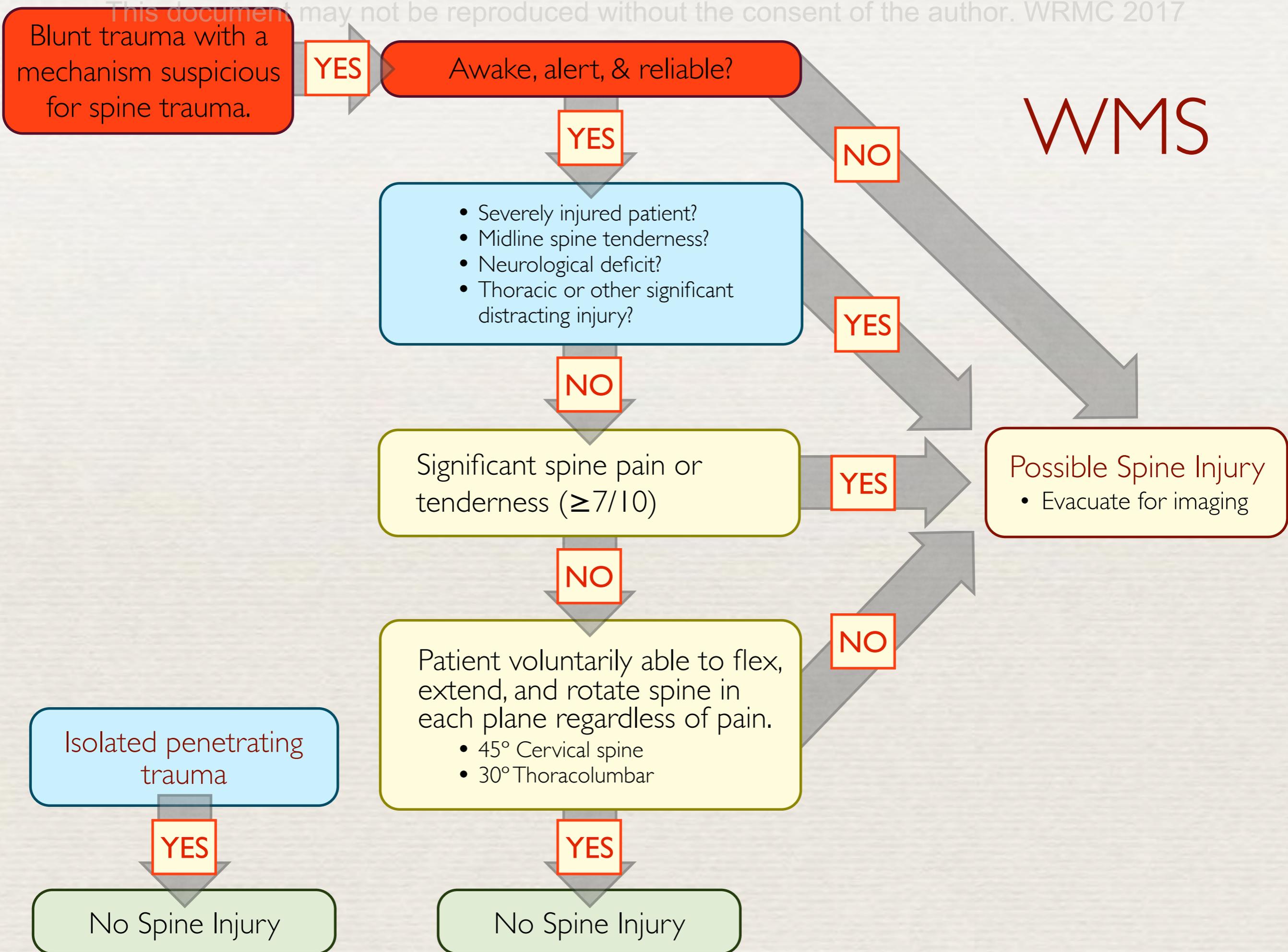
## Modified NEXUS

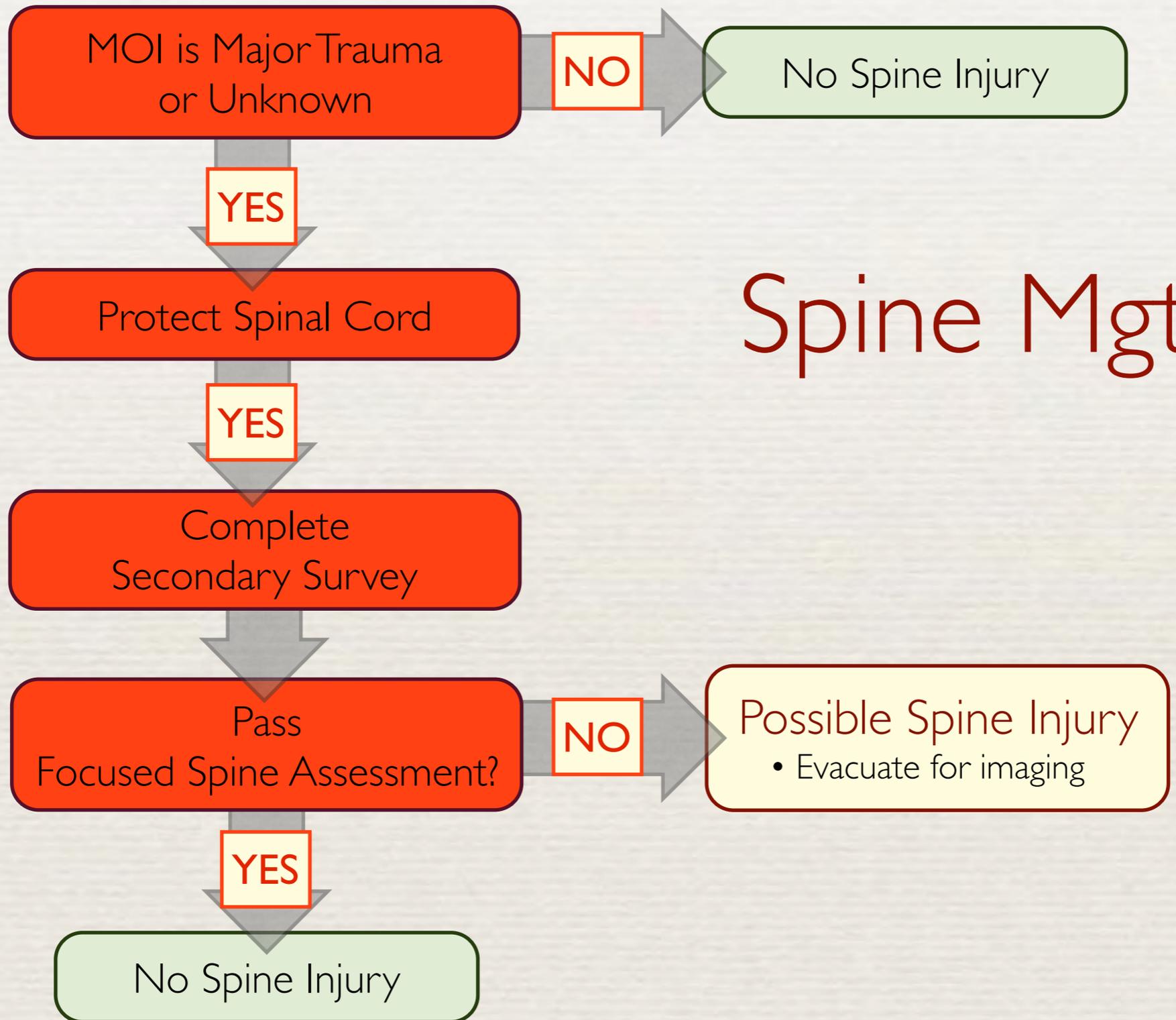
- includes spine pain
- applies to the entire spine

## State of Maine Protocols

- includes spine pain
- includes paraspinal tenderness
- applies to the entire spine

# WMS





# Spine Mgt

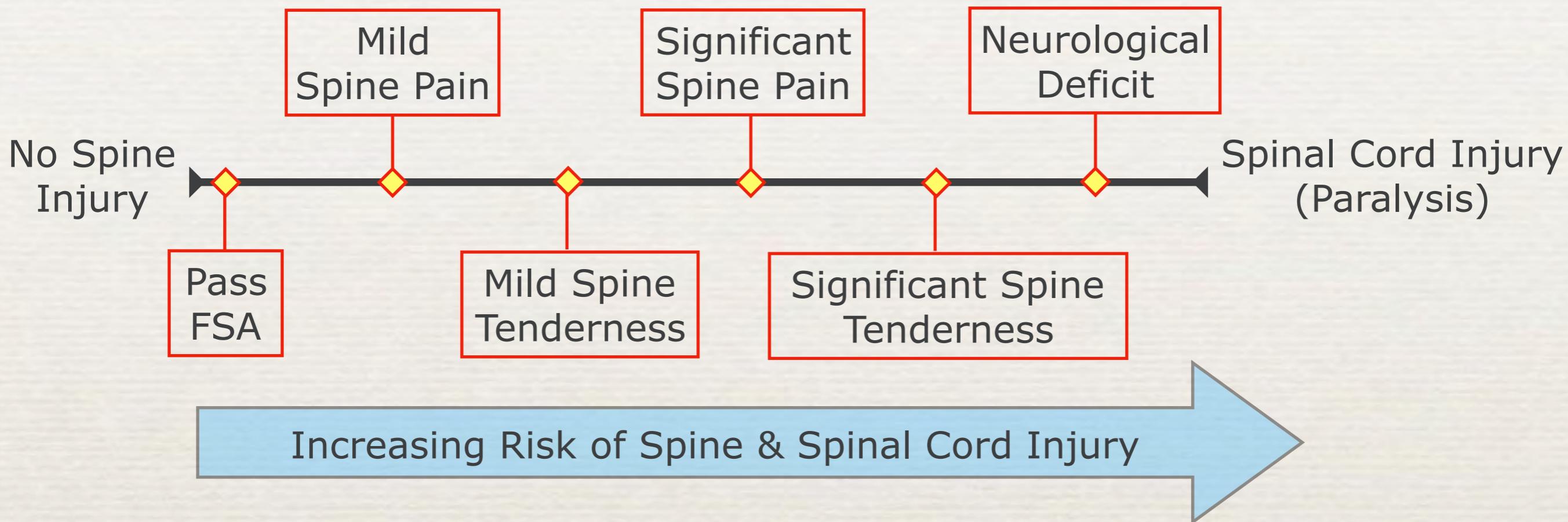
# Spine Management after a failed Focused Spine Assessment

- ◆ Voice-responsive, pain-responsive, and unresponsive patients should be evacuated in a litter or stretcher with spinal cord protection using a full-body vacuum splint. If a vacuum splint is unavailable, use thick, soft materials for padding under the patient and around their head, neck, and body to support their spine and minimize energy deposition to injured tissues during the evacuation.



- ◆ Assess risks associated with a litter evacuation keeping in mind that the positive predictive value of the FSA is roughly 4%.
  - Consider a self-evacuation for all awake and ambulatory patients.
  - Non-ambulatory awake patients will need to be carried out: Consider using a backpack-type carry versus a litter or stretcher.

# Spine & Spinal Cord Injury Assessment



## Additional Risk Considerations

- ◆ **BIG** traumatic MOI
- ◆ Rough, high-risk evacuation terrain
- ◆ Additional patient injuries (simple extremity injuries versus critical system injuries)
- ◆ SAR response
- ◆ Immediate or impending environmental hazards

# Apparent Discrepancies within EMS

- ◆ Not all EMS agencies use a FSA and there are variations.
  - May cause confusion among responders.
- ◆ Some EMS agencies continue to fully immobilize patients using rigid C-collars and/or backboards.
  - May cause cervical distraction on application and increased ICP and pressure sores in long term. Poorly padded backboards may cause pain and pressure sores. Application of both will delay evacuation.

## Why?

- Some organizations are waiting for more data; some organizations are simply bureaucratic and slow to change.

# Programmatic Considerations

- ◆ Review the FSA with your wilderness medicine provider and physician advisor (if you have one); consider annual, biannual, or quarterly training updates ± simulations for your staff.
- ◆ Review the spine management protocols in the states and EMS systems where you operate; consider your communication and consultation options.
- ◆ Consider writing—or revising—standard operating procedures for spine management for your program.

# Case Study

A-28 year-old man rolls his snowmobile during an high point attempt in the backcountry. The rollover starts a small soft snow avalanche and he and his machine tumble approximately 150 feet before stopping. He is voice responsive with an angulated femur fracture. He winces and groans when you carefully palpate his neck in the C-6 to C-7 region. You are within cell phone coverage and anticipate the arrival of a rescue team within the next 10-12 hours.

# Case Study

A 56 year-old man is swept away in a medium sized soft snow avalanche while skiing in the backcountry. He travels approximately 800 feet and is recovered partially buried. He is awake, alert, and reliable with cervical spine pain (5) and sharp tenderness at C-3. He reports a tingling, electric-like pain in his right arm when his neck moves; he cannot distinguish between pinprick pain and light touch on his right hand; and, there is noticeable weakness on his right side when executing the motor exams on his hands. His remaining injuries are compatible with self-evacuation. Help is roughly eight hours away.

# Case Study

A 34-year-old man is thrown from his horse and lands against a tree with his head and shoulders. Initially unresponsive, he quickly becomes awake, alert, and reliable complaining of neck pain (3) and stiffness. On exam he exhibits mild tenderness at C-5 with no neurological deficit. His remaining injuries are compatible with self-evacuation. The group's satellite phone is malfunctioning and it will take 3-4 days to contact and bring in a rescue/evacuation team; if you continue with the trip as planned, you will be out within two days.

# Case Study

A 22-year-old kayaker running a 14 foot vertical waterfall pitons her boat at the bottom of the drop. The water pounding on her head, neck, and shoulders forms an air space in front of her head and eventually pivots her boat off the obstruction and into the pool below the drop where she rolls upright and paddles to shore. Once on shore, she complains of pain (3) in her low back, neck, shoulders and ankles; her low back is tender. She has no neurological deficit and, although very sore, she thinks she can stand and bear weight on her ankles, and paddle. The gorge is narrow and steep; evacuation by land is not an option; however, there is a small campsite river right in a 1/4 mile; there is no cell coverage. The remainder of the run is mostly Class II water with one mandatory portage.

# Case Study

A 35-year-old climber is hit by falling rock on her helmet on the sixth pitch of a 12-pitch climb. She is initially unresponsive but is awake and groggy by the time you reach the belay ledge. The rock damaged her helmet and she is complaining of severe pain (8) in her neck. Her cervical spine is non-tender but stiff; she has no neurological deficit. She has no neurological deficit. Her remaining injuries are compatible with self-evacuation. From the base of the climb it is an hour hike over third class terrain to your vehicle and another three hours to the hospital. There is no cell coverage. A front is moving in and high winds, rain, and possibly snow are predicted early morning. You have no bivy gear with you; however, sleeping bags, shelter, food and water are in your vehicle.

# Case Study

A 31-year-old female falls while leading a mixed multi-pitch Alpine route in a remote range. She is awake, alert, and reliable with cervical pain (4), tenderness, and no neurological deficit. No outside rescue is possible. Improvising a litter and subsequent evacuation would take multiple weeks. Her remaining injuries are compatible with a self-evacuation.