

# Treatment of Fractures of the Thoracic and Lumbar Spine

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# The spine is a bone like any other, right?

- Many surgeons, of all levels, are averse to the spine
- Fear? Dislike? Not understood?
- Potential for true disasters

# The spine is a bone like any other, right?

- But approached like any other system it can be safely and comfortably managed
- Take time to understand some basic fundamentals
- Anatomy, clinical examination, history and image interpretation – as you would for any other bone or joint!
- It may be easier to decide NOW to get a handle on it rather than trying to avoid – it will find you!
- You might even end up choosing to develop spine as your sub-specialty area of expertise.....

# The spine is a bone like any other, right?

- However you feel about it, and with no exception, every other orthopaedic system is completely redundant without a functioning spine
- So let's get at it!!



# Objectives

1. Identify spine **anatomy** and factors involved in spine **stability**
2. Classify fracture according to **AO** and **Thoracolumbar spine injury classification** and severity score
3. Describe **treatment** pathways for all injury types including **red flag** and **special conditions**
4. Discuss common **complications** and their management

# Initial Assessment

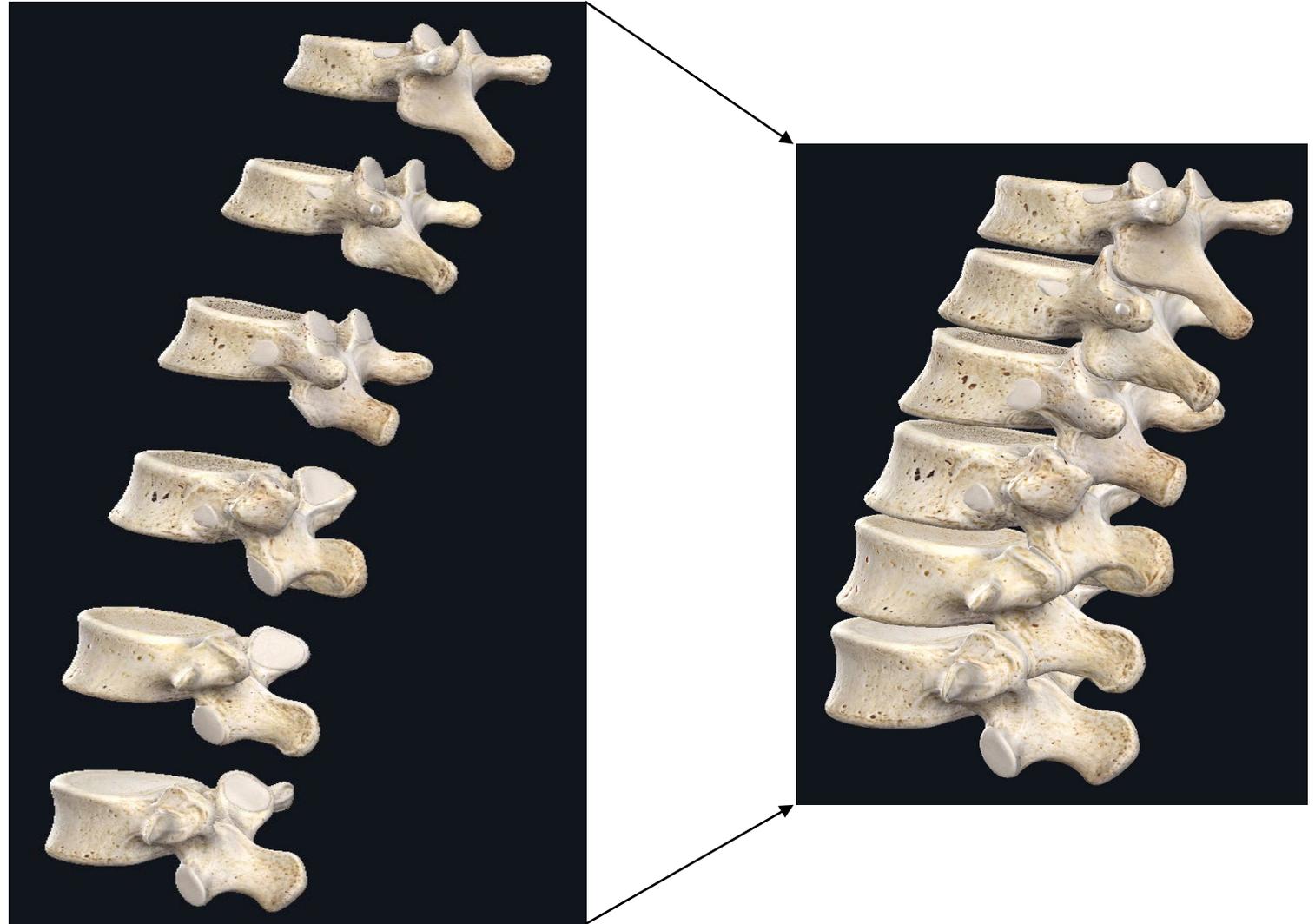
- The spine is a bone like any other: history, physical, image
- Holistic approach -> Advanced Trauma Life Support (ATLS) principles, synchronized with trauma teams, radiology, intensive care
- History – Mechanism of Injury: axial load, hyperflexion, combined mechanism, penetrating
- Previous spine surgery, pre-event back pain, history of malignancy, spondyloarthropathy (eg, Ankylosing spondylitis)
- Low energy - Could it be pathological?

# Initial Assessment

- Check for other fractures, cervical spine, pelvis, long bones
- Focused neurological assessment including sacral nerve roots, post-void residual urine volume
- Get patient off spinal board as soon as possible without compromising safety:- beyond 20 minutes the risk of pressure sore development rises dramatically
- In collaboration with all trauma teams, determine appropriate type and timing of imaging

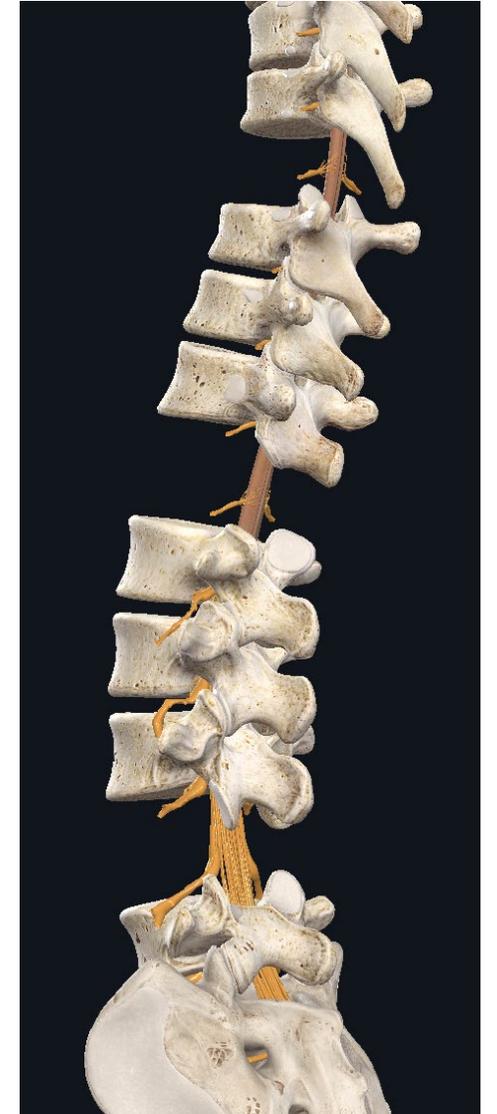
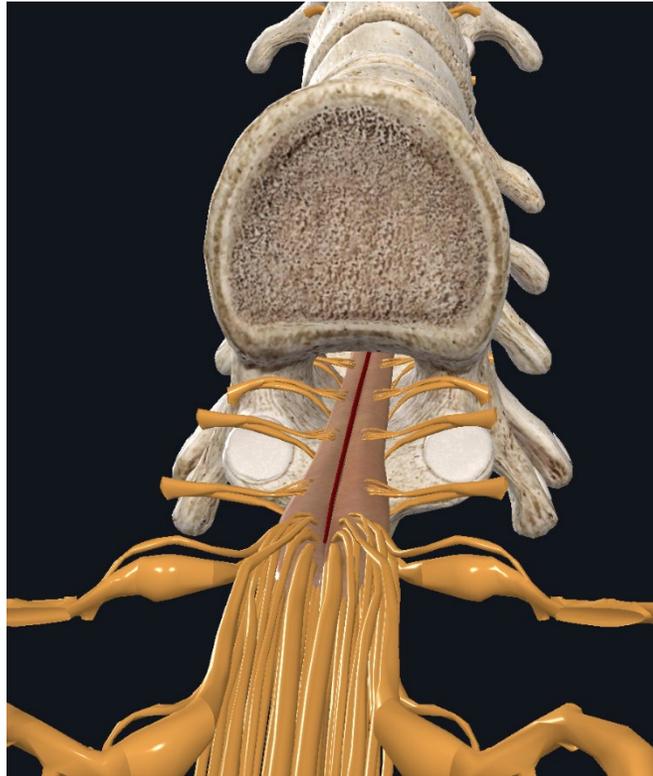
# Anatomy

- Blocks of bone stacked on top of each other allowing multiplanar motion
- Blocks shape provide gross form, alignment and some stability

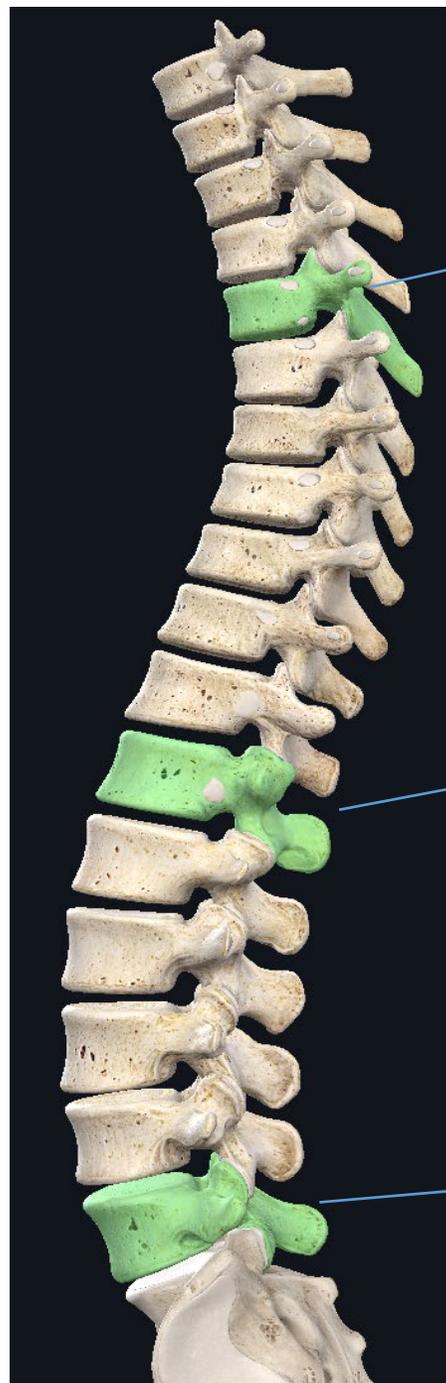


Spinal cord  
Conus medularis  
Cauda equina  
Anterior spinal artery  
(Posterior spinal arteries x2)  
Nerve roots

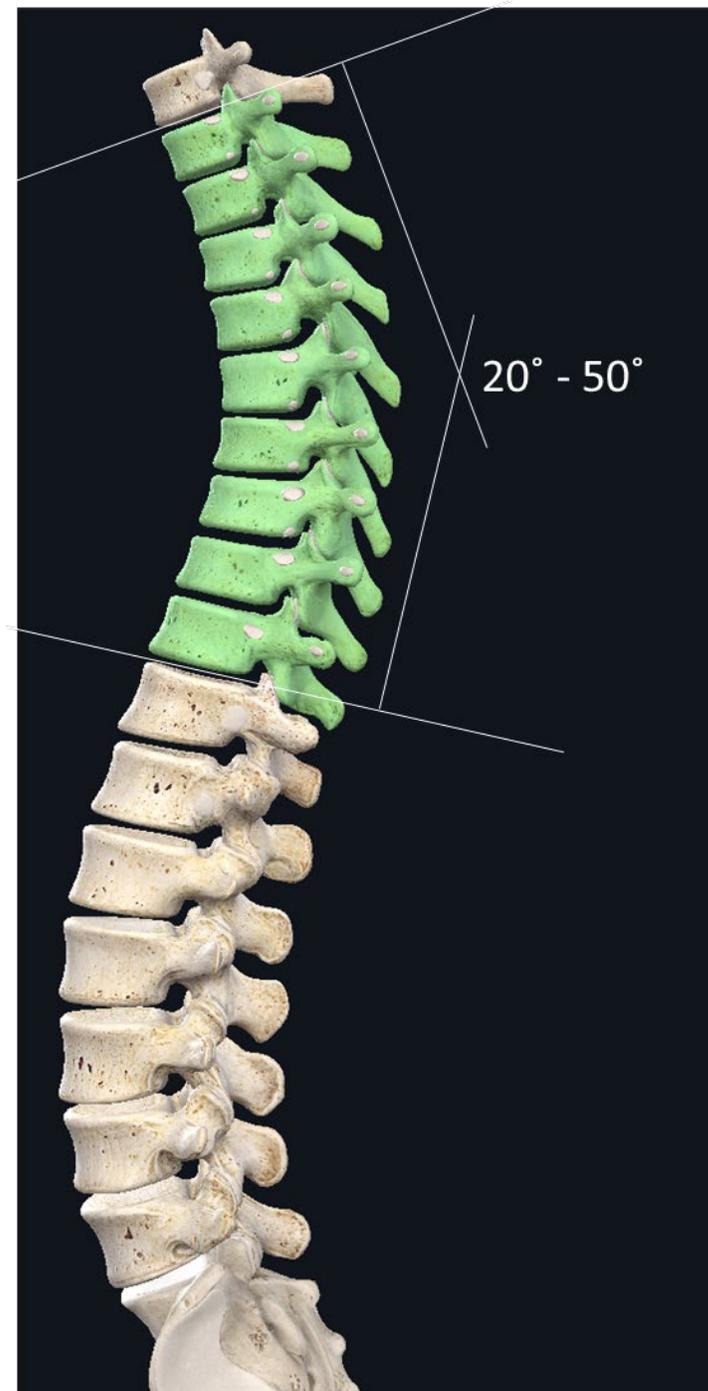
## Neural elements



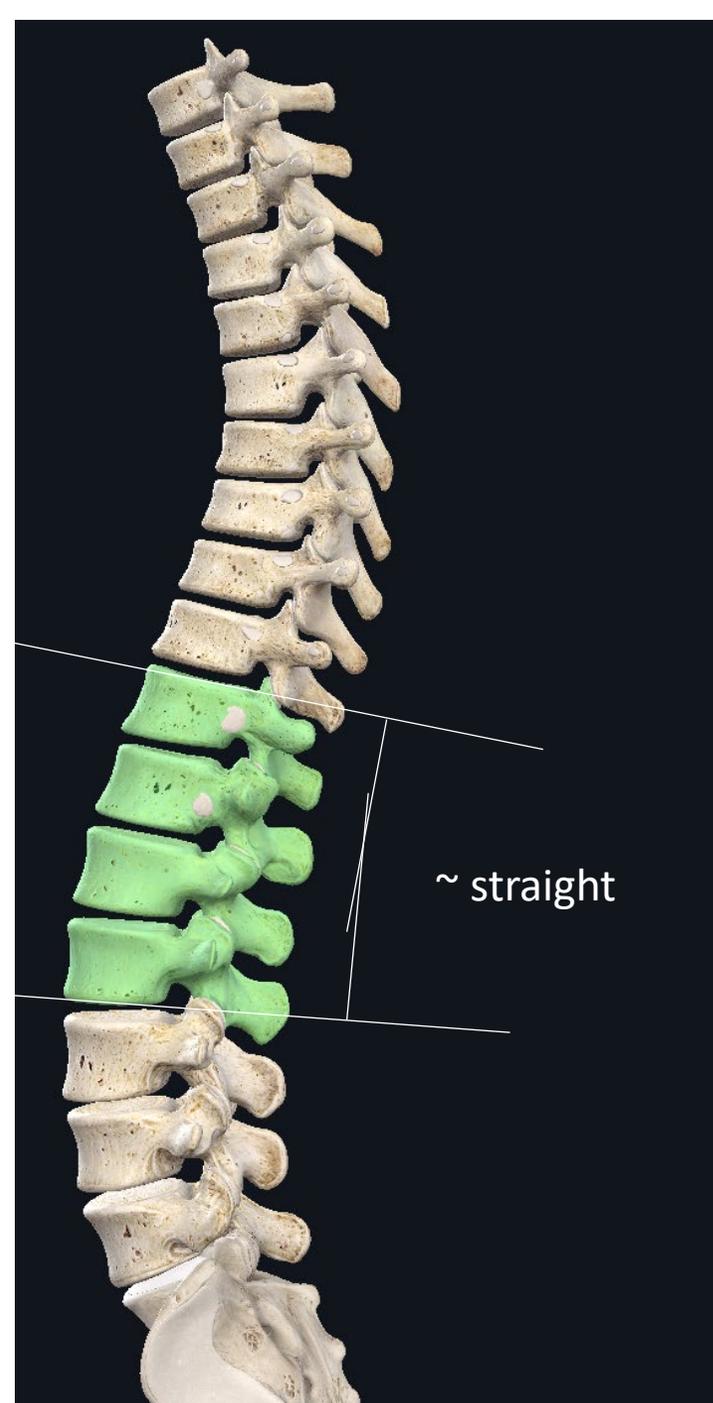
- Vertebral body sizes increase from cranial to caudal in the thoracolumbar (TL) spine
- Narrowest at T4, pedicle diameter increases cranially to T1 and caudally to T12
- Lumbar pedicle size increases from cranial to caudal (note:T12 may be wider than L1)



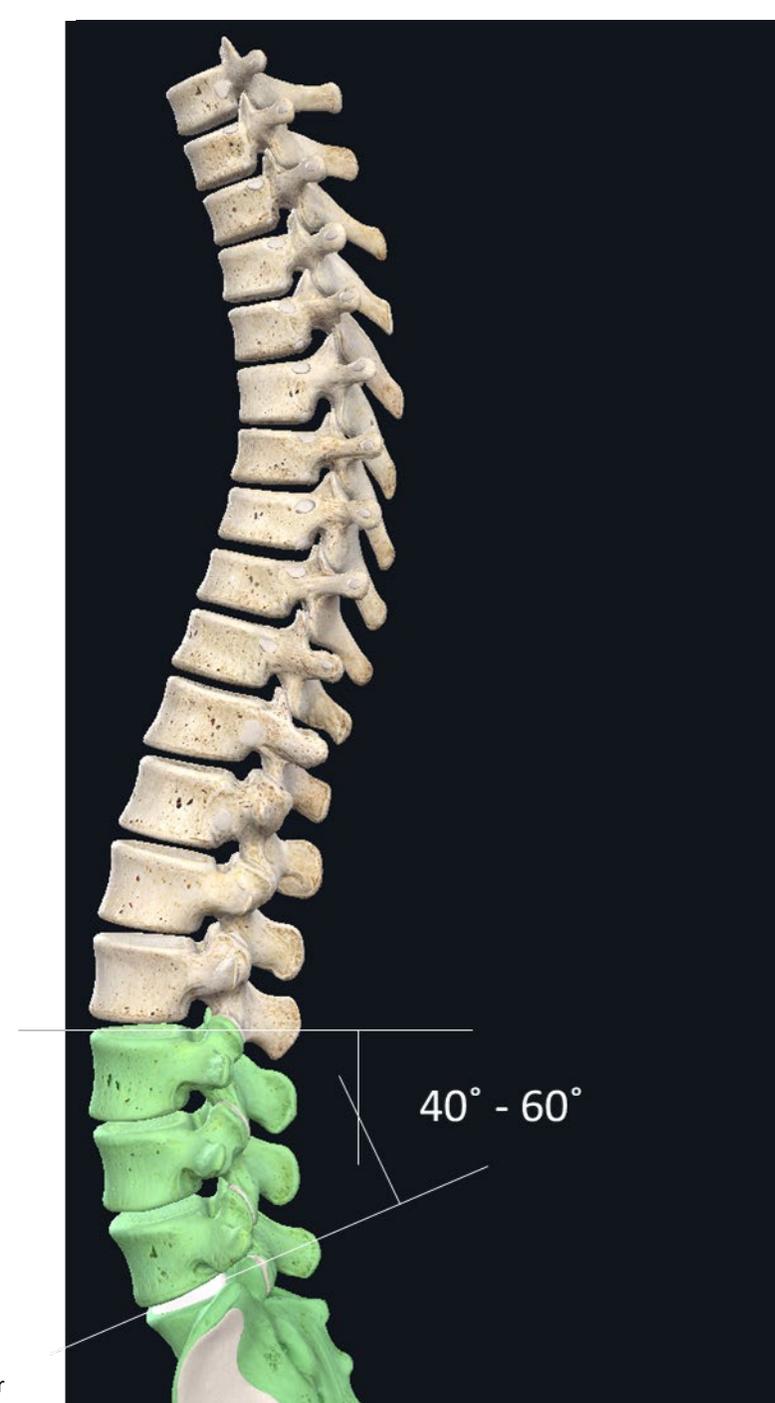
- Thoracic spine (T2 – T10) kyphosis range 20° to 50°



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- Thoracolumbar junctional area (T11 – L2) is relatively straight/flat



- Thoracic spine (T2 – T10) kyphosis range 20° to 50°
- Thoracolumbar junctional area (T11 – L2) is relatively straight/flat
- Lumbar lordosis (L3 – S1) range is 40° to 60°



# *“ties that bind”*

The key instruments of mechanical restraint are the connective tissues:-

- Intervertebral discs
  - Ligaments
  - Joint capsules

Intervertebral disc

Anterior longitudinal ligament

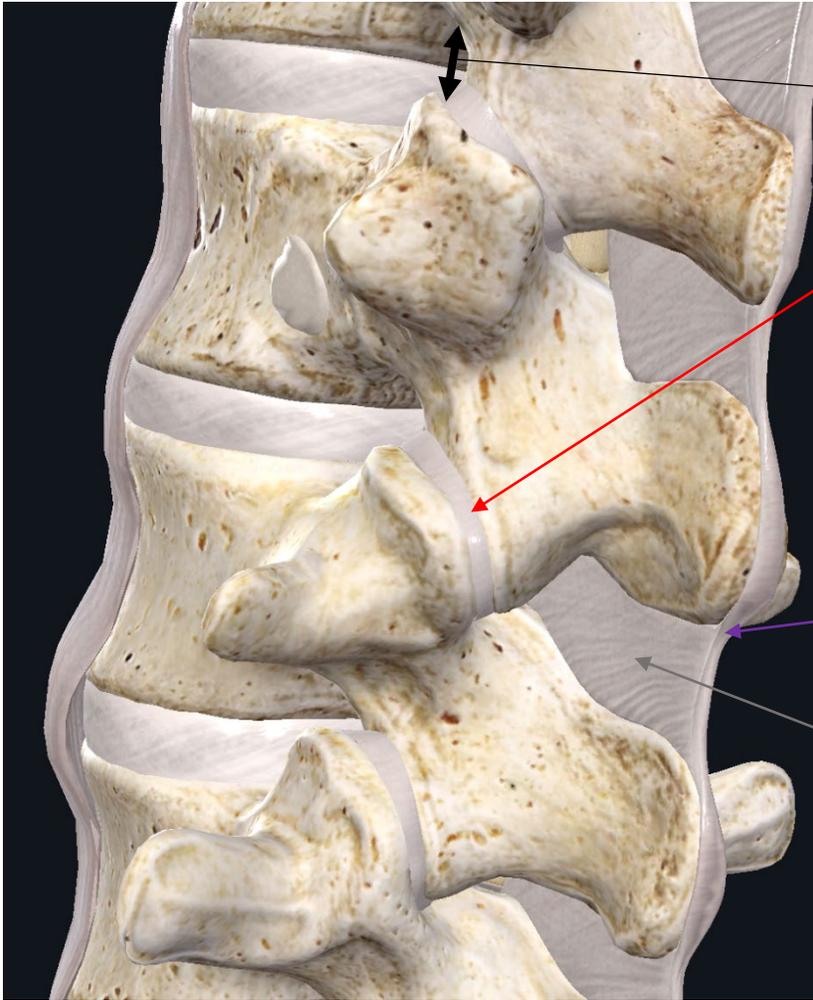
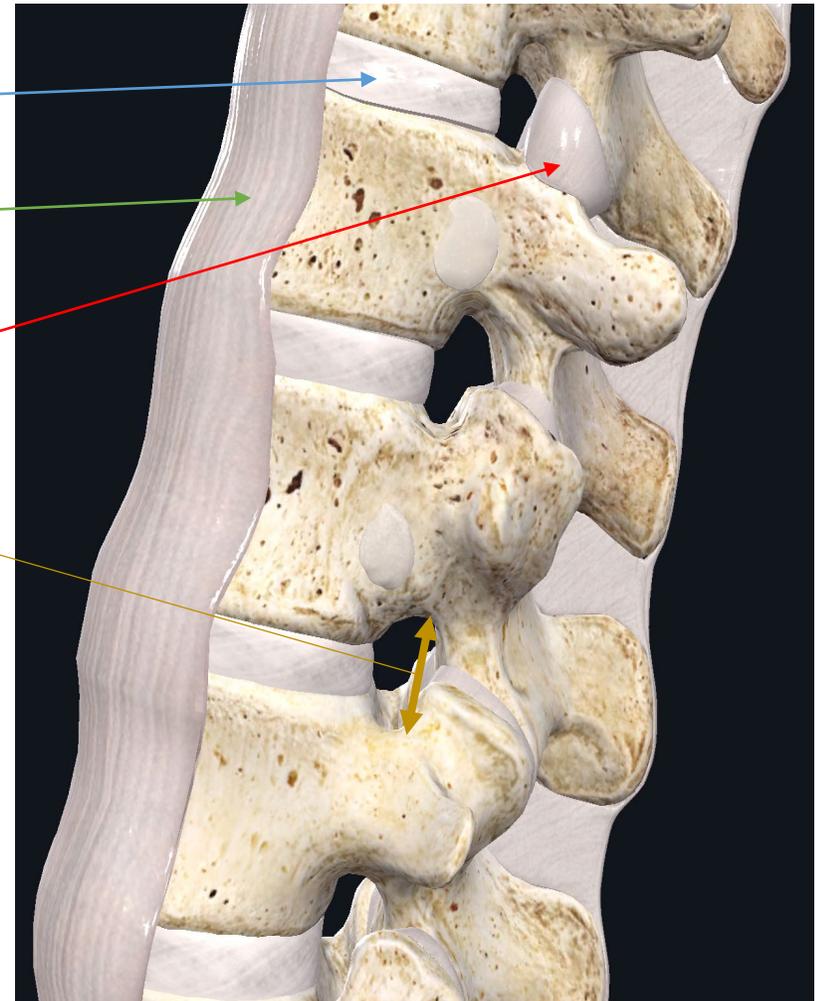
Posterior longitudinal ligament (hidden)

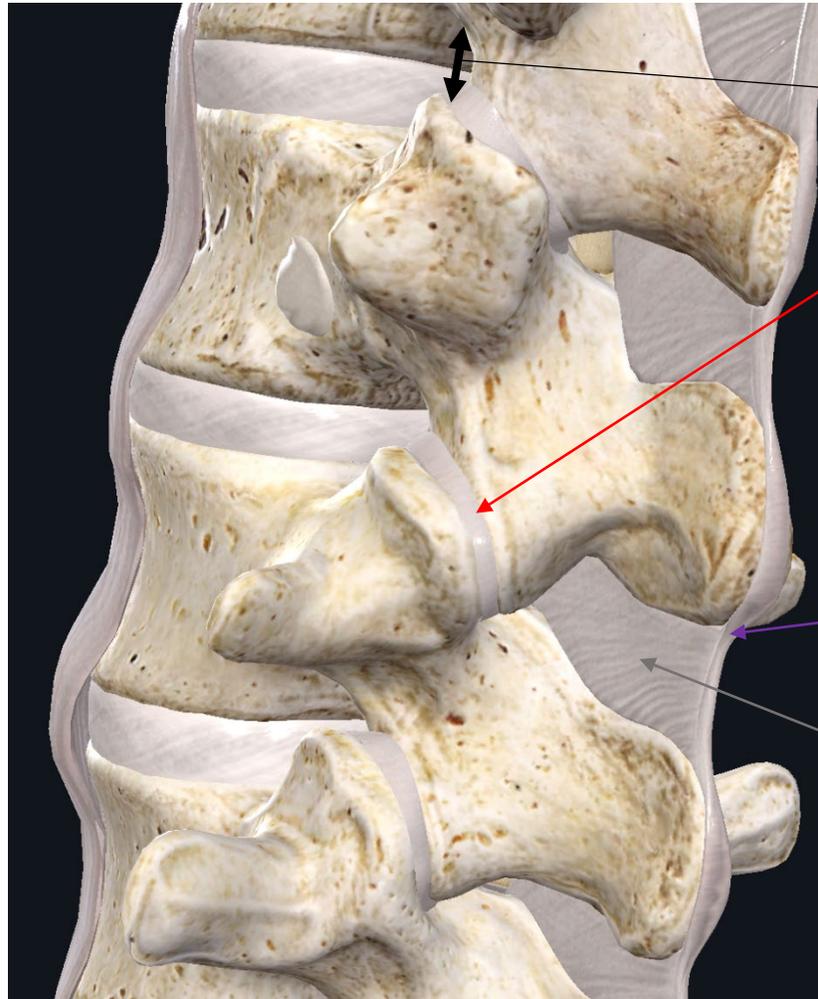
Facet joint capsule

Ligamentum flavum (not seen)

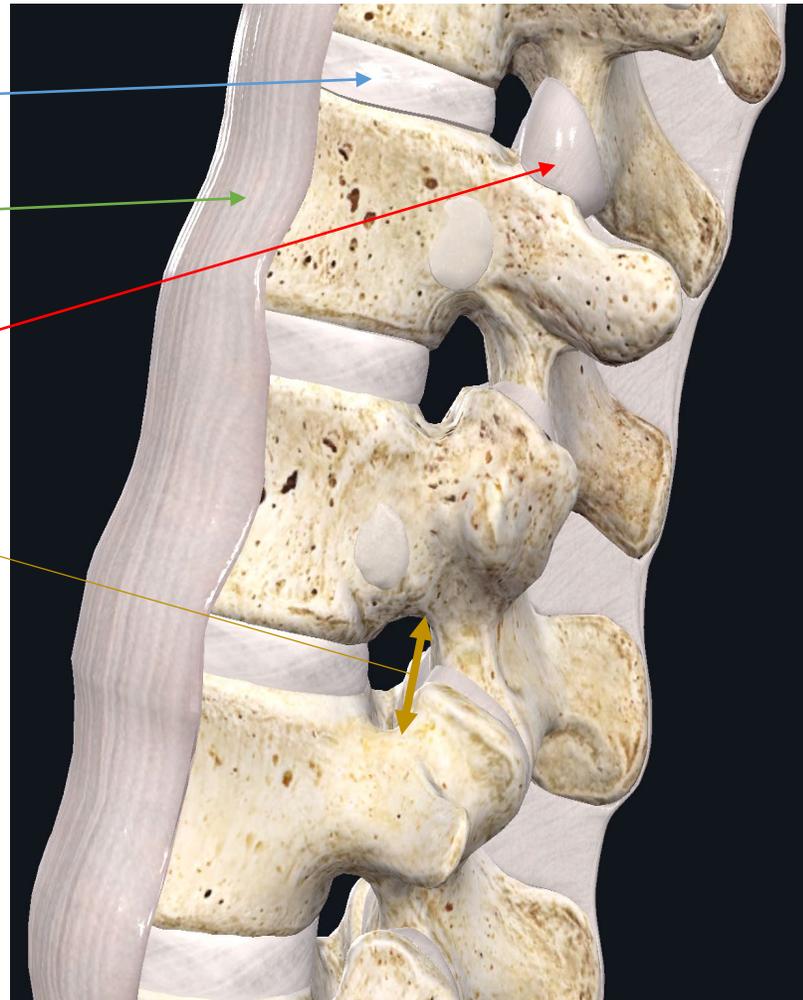
Supraspinous ligament

Interspinous ligament

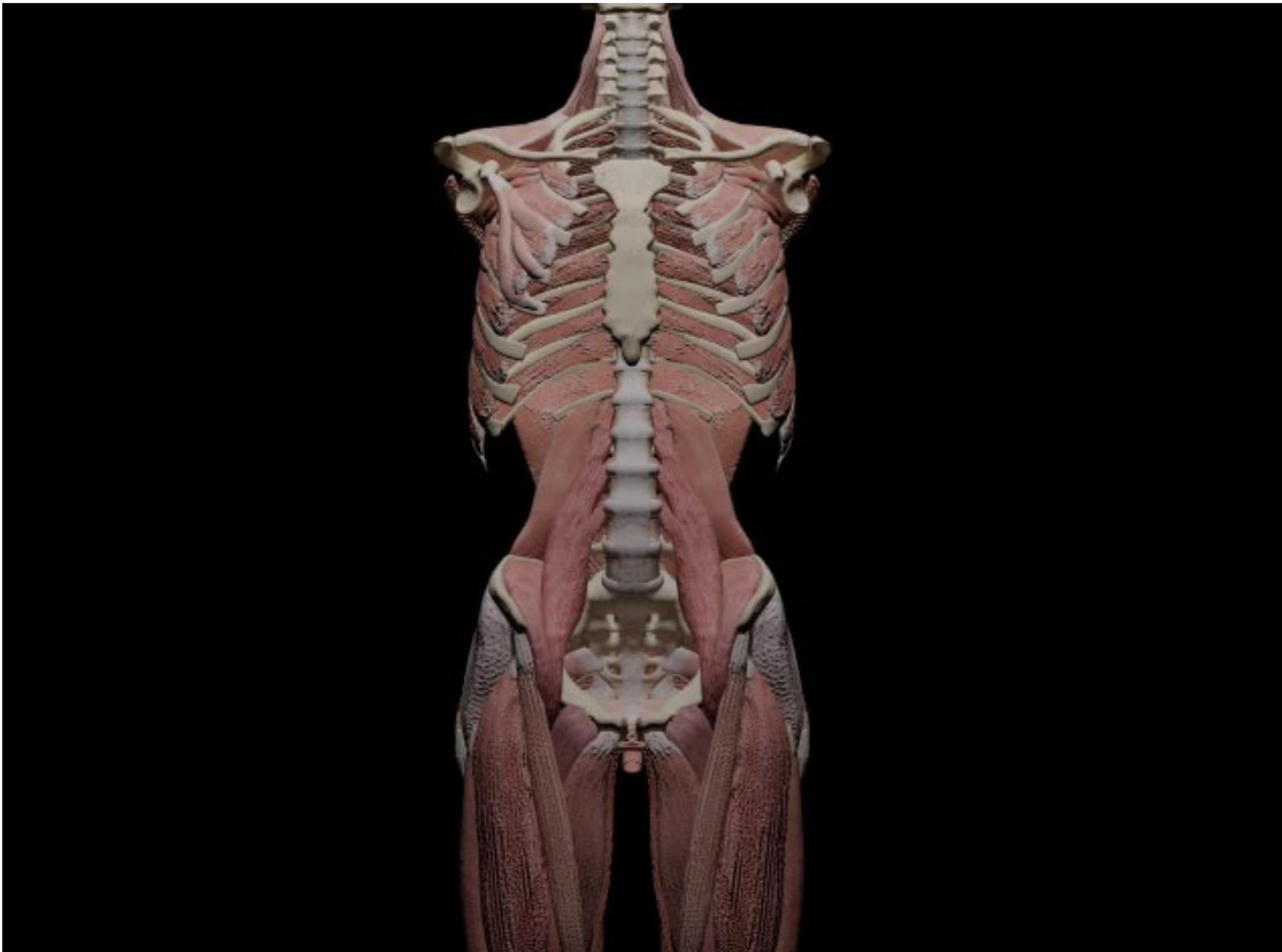




- Intervertebral disc
- Anterior longitudinal ligament
- Posterior longitudinal ligament (hidden)
- Facet joint capsule
- Ligamentum flavum (not seen)
- Supraspinous ligament
- Interspinous ligament



# POSTERIOR LIGAMENTOUS COMPLEX (PLC)



Movie animation overview of anatomy

Movie animations reproduced with permission Radiological Society of North America and Bharti Khurana, MD  
Traumatic Thoracolumbar Spine Injuries: What the Spine Surgeon Wants to Know. Bharti Khurana, Scott E. Sheehan, Aaron Sodickson, Christopher M. Bono, Mitchel B. Harris.  
RadioGraphics 33:2031-2046. 2013



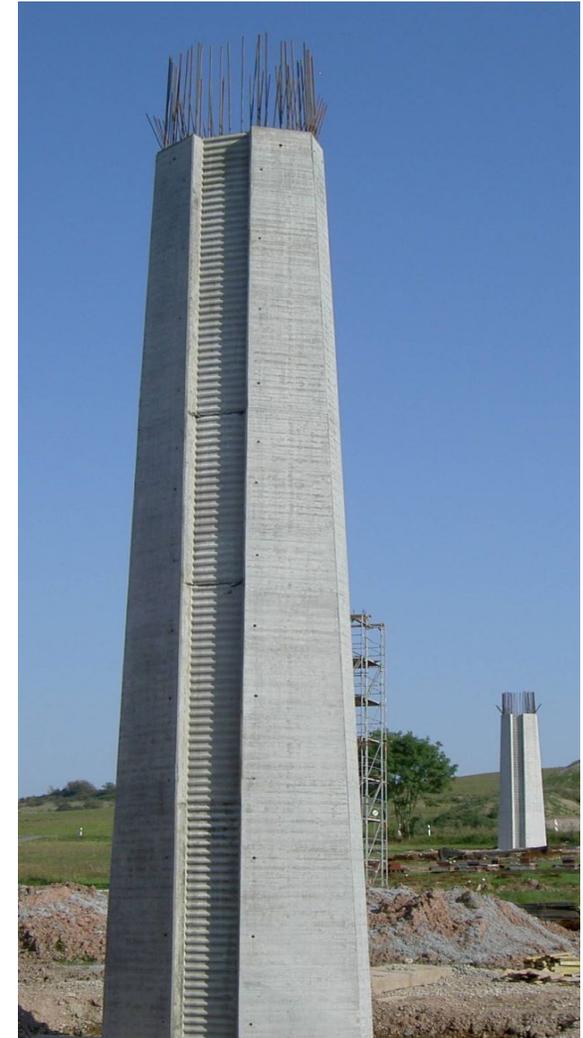
**This upright for a railroad bridge is constructed of steel mesh and concrete.**

**How do you think it would perform under mechanical load if:-**

- a) Only the concrete was compromised?**
- b) Only the steel mesh was compromised?**
- c) Both were compromised?**

**Can you relate this to the spine if we substitute bone for concrete, and ligament for steel mesh:-**

- a) Pure axial force?**
- b) Pure bending force?**
- c) Combined force?**



- Any event, intrinsic or extrinsic in origin, which disrupts anatomy has the potential to compromise stability
- Examples of intrinsic events are spontaneous fracture of a spinal segment under physiological load secondary to malignancy, metastases, osteoporosis
- Extrinsic origin events are the result of forceful energy imparted on the spine during a traumatic event such as a fall, MVC, direct impact
- Intrinsic diseases (e.g. **ankylosing spondylitis**, **osteoporosis**) can significantly increase vulnerability to an external force
  - Anatomical disruption may be purely bony, purely connective tissue, or combined

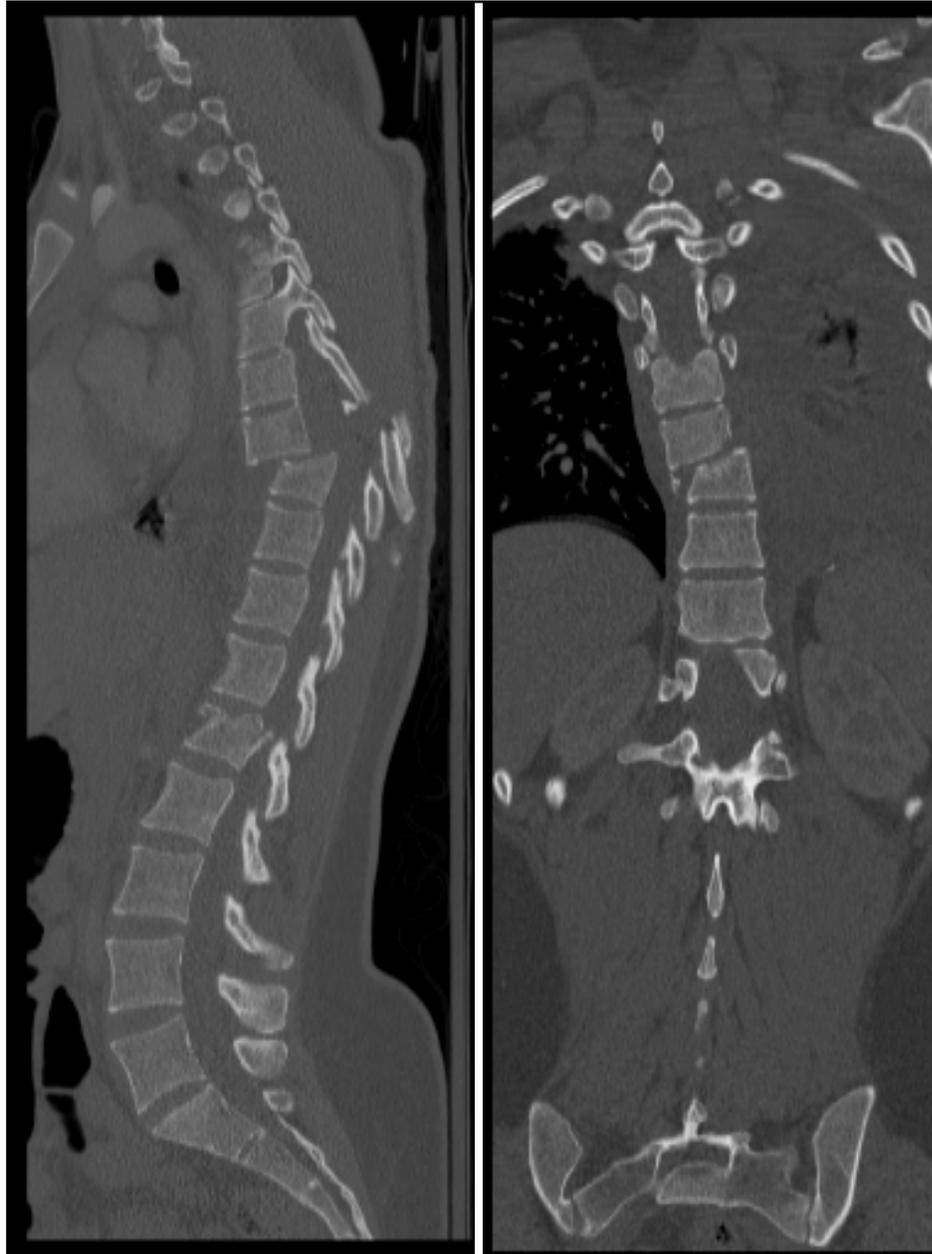
# Thinking of *stability*

- **Mechanical** → *capacity to maintain structural integrity under load*
- **Neurologic** → *ability of spinal cord, cauda equina and nerve roots to function normally*

*Growing appreciation of spinal contribution to:*

- **Physiologic** → as per long bone or pelvis fractures, *especially* in polytrauma
- **Respiratory** → ventilatory splinting, patient positioning - supine vs. upright
- **Soft tissue** → decubitus ulcers, pressure sores

- Mechanical →
- Neurologic →
  
- Physiologic →
- Respiratory →
- Soft tissue →



Case 1: 21 year old female, MVC rollover

Clearly **mechanical** stability has been lost as demonstrated by T8/9 fracture-dislocation.

However, and remarkably, she had preserved **neurologic** spinal cord, cauda equina and nerve root function.

She is **physiologically** unstable due to not just ongoing hemorrhage, but also non-reduced fractures and dislocation.

She has **respiratory** instability not just due to left sided hemothorax, but also pain splinting and immobilization in a supine position.

Her **soft tissues** are at high risk due to the extreme peril of attempting to move her.

- Mechanical →

- Neurologic →

- Physiologic →

- Respiratory →

- Soft tissue →

This example is very clear and determination of stability can be made comfortably and quickly.

Almost.

What about the L1 vertebral body;  
it is clearly fractured, but is it stable or not?

We know she is **currently** neurologically stable,  
but based on only 2 CT slices presented above we cannot  
conclusively determine  
L1 mechanical stability.

How do we address this and other similar situations?



- **Static imaging:**

- XR – gross morphology and alignment

- asymmetric widening adjacent spinous processes

- CT - sagittal, coronal and axial alignment

- canal retropulsion and neural element compression

- facet, pedicle and lamina fractures

- facet joint widening

- MRI - ligament disruption

- neural element compression and signal change

- hematoma

- facet joint edema

- **Dynamic imaging:**

- XR – upright radiographs

- flexion/extension radiographs

How about this next case,  
again some CT images.

Lets look closer now....

the information is there, but subtle.

It is critical, however!

Case 2: 25 year old male, high energy fall, neurologically intact



Mid sagittal showing relative spinous process widening between T11-12

Subtle A1 type fracture of anterior superior vertebral body endplate



Right T11/12 facet joint capsule compromised with perched facet joint

## Stable or not?

Well, think back.....

The spinous processes are splayed and widened asymmetrically, and a facet joint has perched open

Therefore the PLC must be violated as it can no longer maintain its structural integrity from the forceful high energy hyperflexion mechanism

Anteriorly there is also an A1 type fracture however taking it all together it is a T11/12 B2.N0;T12 A1 type injury



# Goals of Surgery



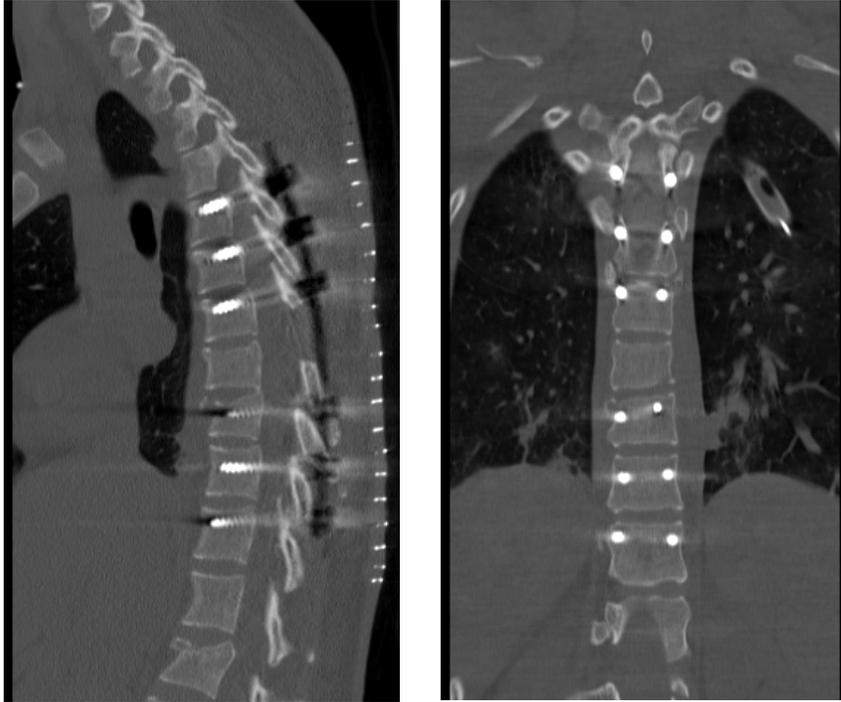
## Restore stability - directly

- Reduce dislocation
  - Correct sagittal and/or coronal balance
- Provide mechanical augment, support and buttress
- Promote bone and soft tissue biology and fusion
  - Decompress and protect neural elements

## Restore stability – indirectly

- Enable overall trauma resuscitation, surgical and intensive care
- Facilitate early mobilisation, patient positioning and ventilation
- Protect from pressure sores, decubitus ulceration and thromboembolism

21 year old female, MVC rollover



Clinical case and images courtesy of Jeremie Larouche, MD

25 year old male, high energy fall



Clinical case and images courtesy of Albert Yee, MD

Post-operative imaging of Case 1 and 2 above:-

Have goals of surgery been achieved?

# Structural stability

- Decompression of *neural elements*
- Instrumentation of *spinal segments*
- Fusion to stabilize across levels



This upright for a railroad bridge is constructed of steel mesh and concrete.

How do you think it would perform under mechanical load if:-

- Only the concrete was compromised?
- Only the steel mesh was compromised?
- Both were compromised?

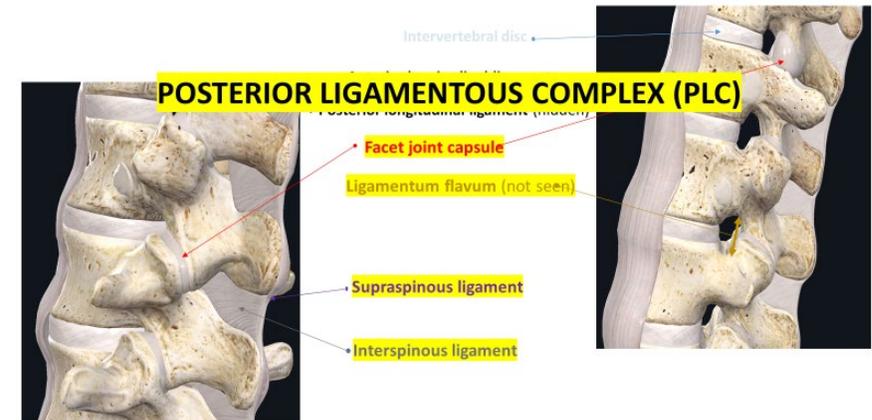
Can you relate this to the spine if we substitute bone for concrete, and ligament for steel mesh:-

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Core Curriculum V5



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Core Curriculum V5



Core Curriculum V5

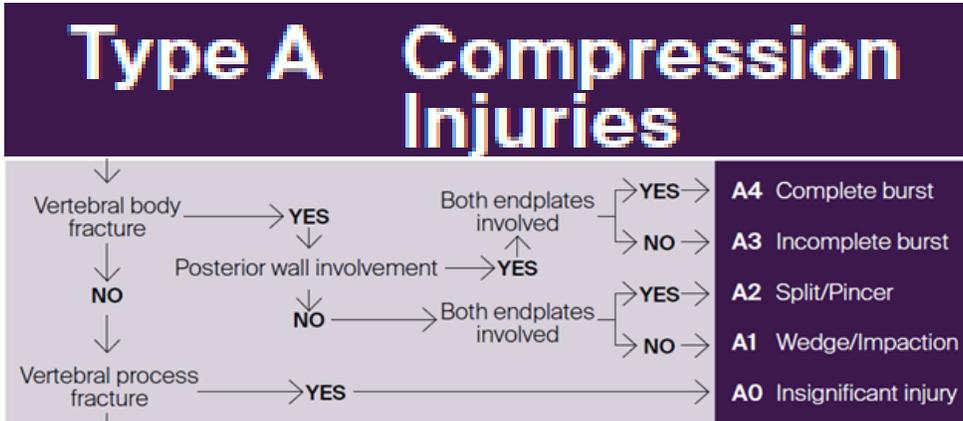
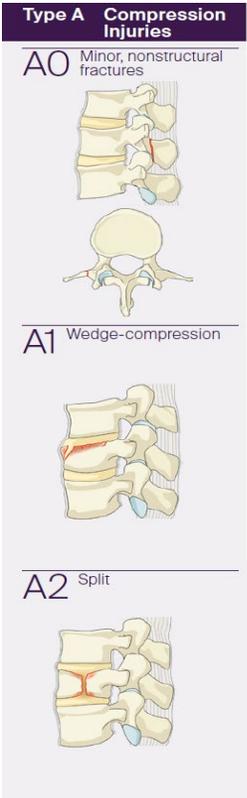
# Physiological stability

- Fracture and or dislocation has systemic impact; as per long bones, pelvis
- Inflammatory pathway activation and perpetuation – multiorgan dysfunction
- Respiratory splinting and ventilatory impairment - pneumonia
- Pressure sores: +++ impactful; sepsis, multiple surgeries
- Thromboembolic events

Endeavour to reduce and stabilise as *early as safe* to do so – the same principles that we apply to long bones and pelvis

Complications are reduced with a protocol to standardize timing of fixation based on response to resuscitation. Heather A. Vallier, Timothy A. Moore, John J. Como, Patricia A. Wilczewski, Michael P. Steinmetz, Karl G. Wagner, Charles E. Smith, Xiao-Feng Wang, Andrea J. Dolenc. Journal of Orthopaedic Surgery and Research. 10(155) 2015

Early fixation of traumatic spinal fractures and the reduction of complications in the absence of neurological injury: a retrospective cohort study from the American College of Surgeons Trauma Quality Improvement Program. Guttman M., Larouche J., Lyons F, Nathens A. J Neurosurg Spine Aug 28;1-10. 2020

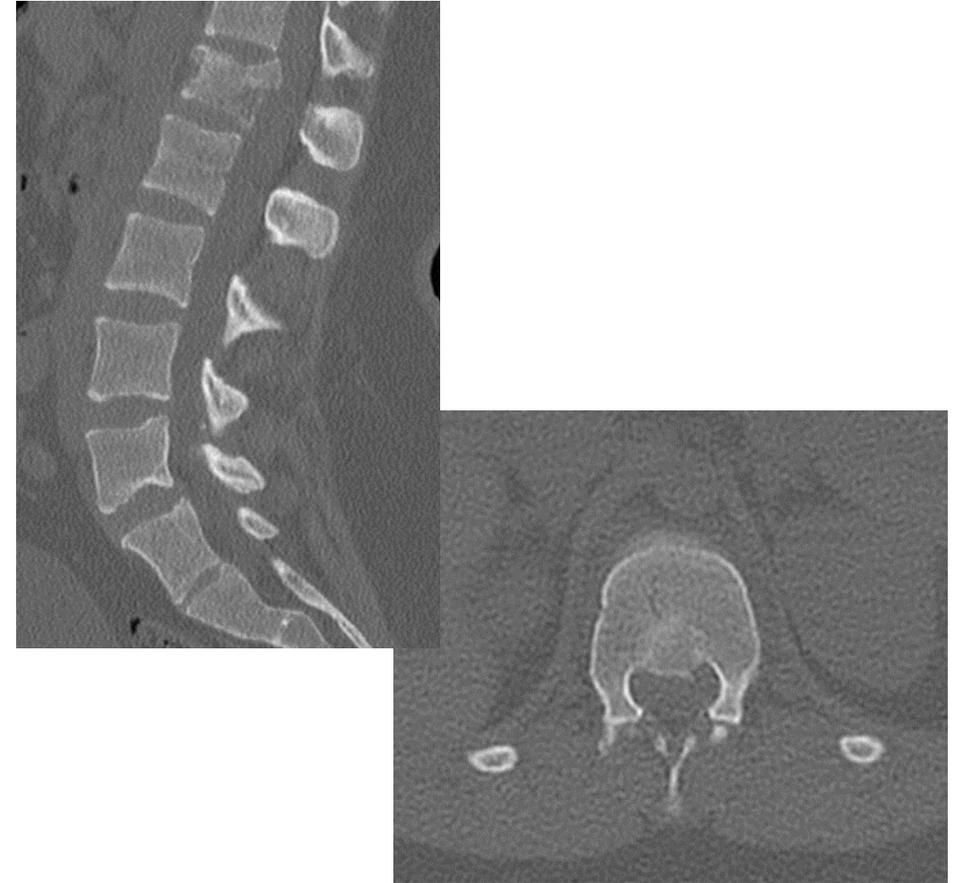


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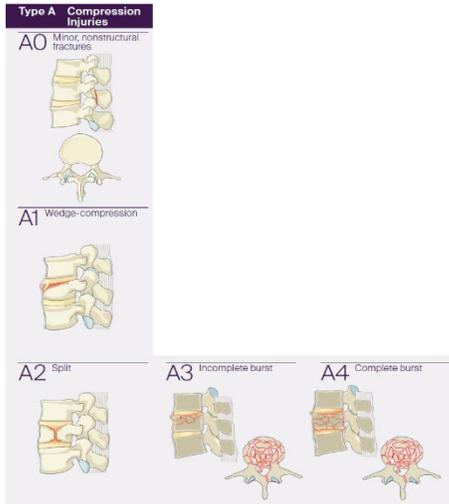
Case 3: 24 year old male, fall horse riding.

Isolated L1.A3.N0 type injury (incomplete burst fracture). Patient presented day three post injury due to localised back pain, but ambulating independently.

What would push you towards either an operative or non-operative care plan?



Clinical case and images courtesy of Keith Synnott, MD

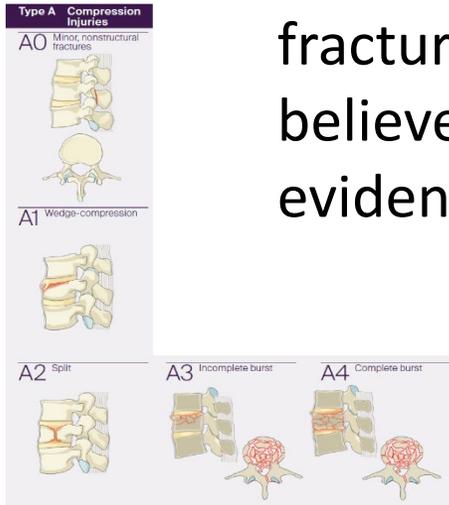


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The reality is these occupy a grey area: neurologically intact lumbar burst fractures with indeterminate posterior-ligamentous complex integrity.

Advocates for surgical stabilisation cite delayed, progressive kyphosis as the fracture collapses and heals. Those against believe that, in the absence of instability, evidence supports non-operative care.



Nonoperative versus operative treatment for thoracolumbar burst fractures without neurologic deficit: a meta-analysis. Sonali R Gnanenthiran, Sam Adie, Ian A Harris. Clin Orthop Relat Res Feb;470(2):567-77, 2012

Clinical case and images courtesy of Keith Synnott, MD

Operative compared with nonoperative treatment of a thoracolumbar burst fracture without neurological deficit: a prospective randomized study with follow-up at sixteen to twenty-two years. Kirkham B Wood, Glenn R Buttermann, Rishabh Phukan, Christopher C Harrod, Amir Mehbod, Brian Shannon, Christopher M Bono, Mitchell B Harris. J Bone Joint Surg Am Jan 7;97(1):3-9 2015

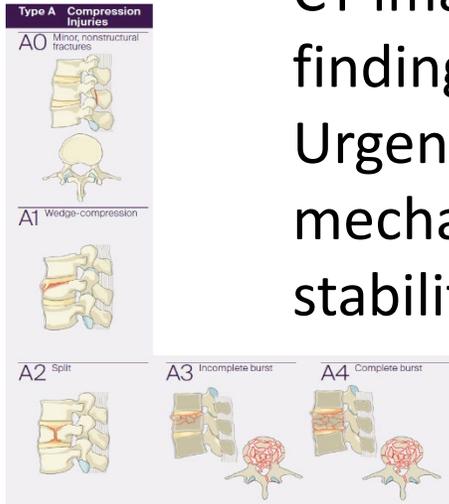


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Case 4: 17 year old male, fall from 5 metre height.

Bilateral calcaneus fractures and clinical acute traumatic cauda equina syndrome.

CT imaging confirmed clinical findings. L3 A4.N3 type injury. Urgent surgery to restore mechanical and neurologic stability.



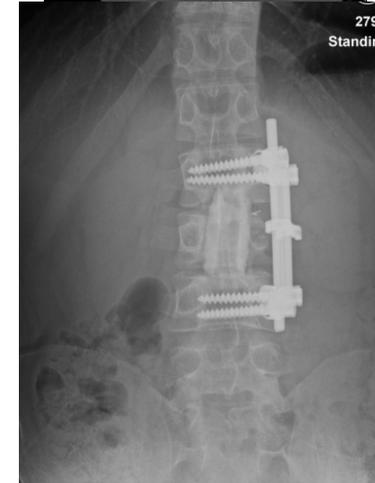
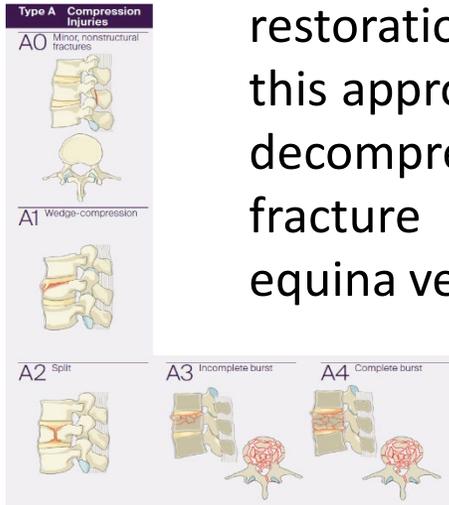
Clinical case and images courtesy of Jeremie Larouche, MD



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Core Curriculum V5

Completely comminuted and compressed multi-fragmentary (A4) fracture of the L3 vertebral body. Height restored with structural tibial allograft spanned with pedicle screws and rods. This was carried out through a direct lateral approach and the (pedicle) screws are laterally inserted in the vertebral body to aid fracture distraction and restoration of vertebral body height. By utilizing this approach it is also possible to carry out a direct decompression by removing the retropulsed fracture fragments from impinging the cauda equina ventrally.



Clinical case and images courtesy of Jeremie Larouche, MD

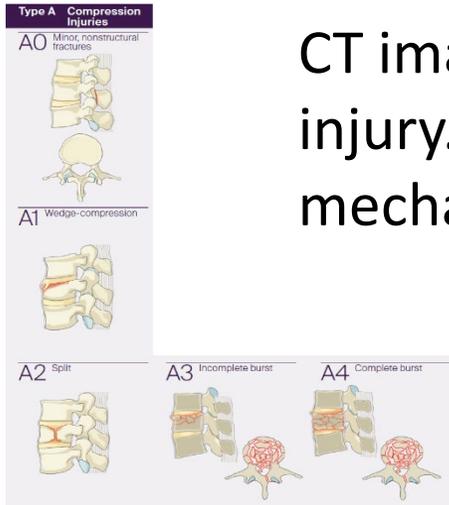


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Case 5: 32 year old female, fall  
rock climbing

Isolated injury and neurologically  
intact (N0).

CT imaging shows L1 A4 type  
injury. Timely surgery to  
mechanically stabilise.



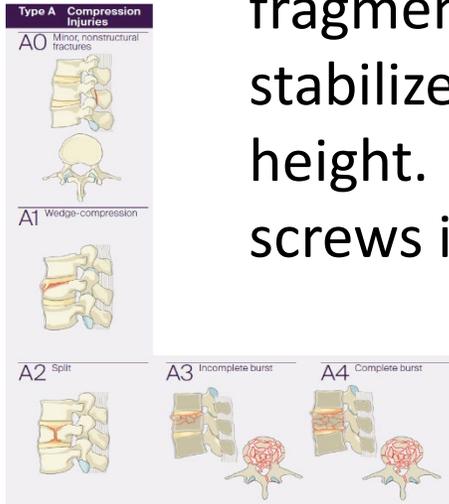
Clinical case and images courtesy of Jeremie Larouche, MD



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Core Curriculum V5

This time mechanical stability was restored through a posterior only approach. In fact, employing a percutaneous technique, ligamentotaxis and instrumentation satisfactorily reduced the retropulsed fragment and restored and stabilized the vertebral body height. Note the shorter pedicle screws in the fractured vertebra.



Clinical case and images courtesy of Jeremie Larouche, MD

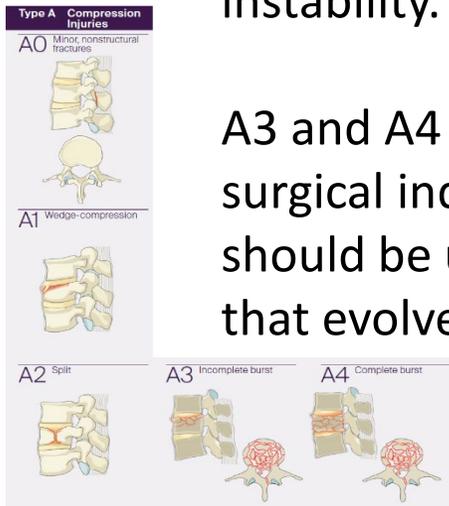


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Type A injuries that do not extend beyond the posterior vertebral body wall on CT are considered appropriate for non-operative care (A0, A1, A2).

Some very displaced A2 types may not heal with non-operative care due to interposed disc between fracture fragments.

With increasing severity of injury the likelihood of posterior ligament complex injury and instability also increases (A3, A4). Upright radiographs demonstrating kyphosis at the fracture level signify instability.



A3 and A4 burst fractures with ++loss of height and intact PLC (pure compression injuries) are relative surgical indications, although high level evidence is lacking. Patient, resource and surgeon factors should be used to plan the course of care. Do also keep up to date with new studies and guidelines that evolve.

Orthosis versus no orthosis for the treatment of thoracolumbar burst fractures without neurologic injury: a multicenter prospective randomized equivalence trial. Christopher S. Bailey, Jennifer C. Urquhart, Marcel F. Dvorak, Melissa Nadeau, Michael C. Boyd, Ken C. Thomas, Brian K. Kwon, Kevin R. Gurr, Stewart I. Bailey, Charles G. Fisher. *The Spine Journal*. 14:2557–2564. 2014

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Movie animations depicting A type injury process

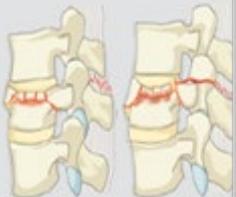
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RadioGraphics 33:2031-2046. 2013

Type B Distraction Injuries

**B1** Transosseous tension band disruption  
Chance fracture



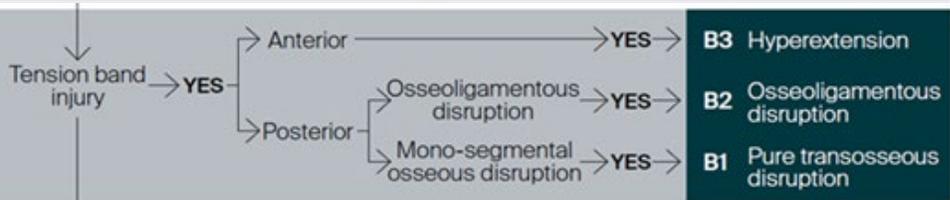
**B2** Posterior tension band disruption



**B3** Hyperextension

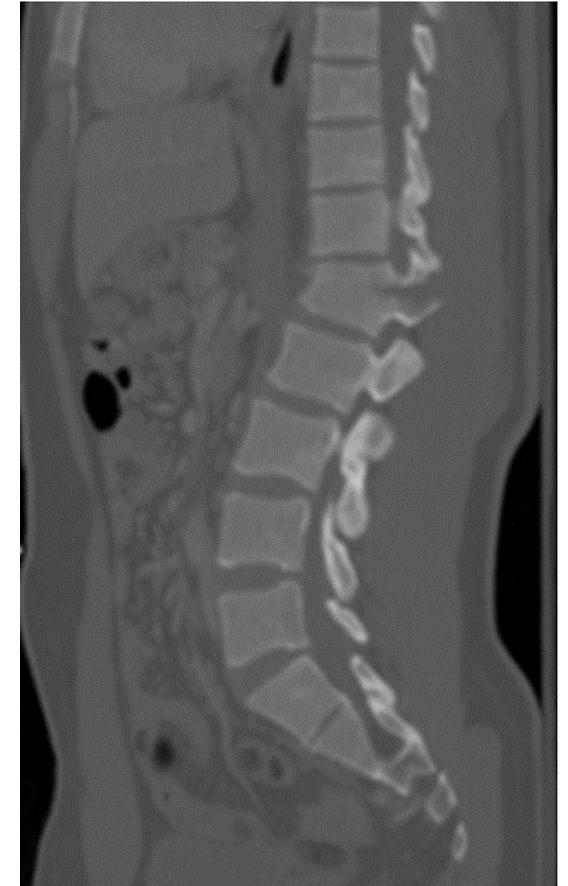
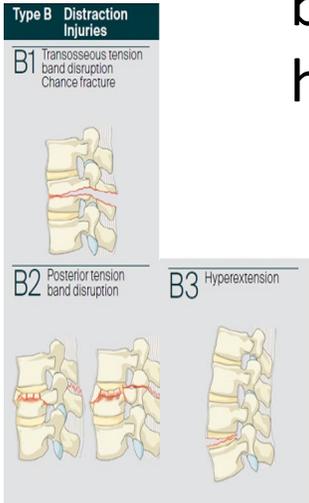


Type B Distraction Injuries



Case 6: 26 year old male, MVC,  
neurologically intact (N0).

Hit a tree at high speed – the  
mechanics of the injury is being  
forcefully “folded” over his seatbelt  
by the rapid deceleration upon  
hitting the tree.

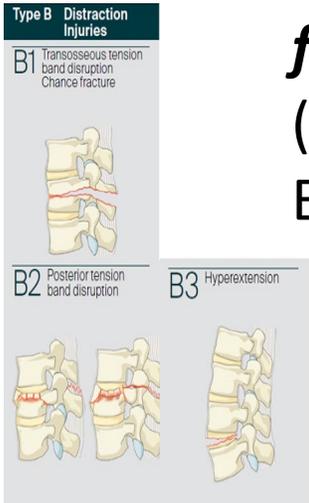
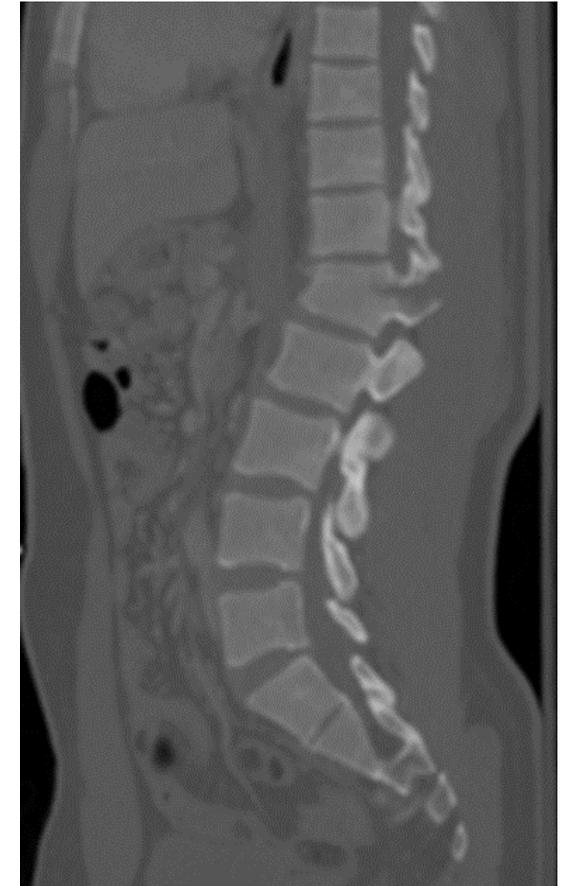


Clinical case and images courtesy of Jeremie Larouche, MD



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The mid-sagittal CT shows a ligamentous component to the injury and the right para-sagittal shows an osseous component, hence a T12/L1 B2.N0 determination (osseoligamentous disruption, neurologically normal). The eponymous term of a **Chance fracture** refers to pure boney injuries (B1). Some surgeons may refer to a B2 as a *soft-tissue Chance injury*.



Note on a type of Flexion Fracture of the Spine. GQ Chance. British Journal of Radiology 21(249)452-452. 1948

Clinical case and images courtesy of Jeremie Larouche, MD

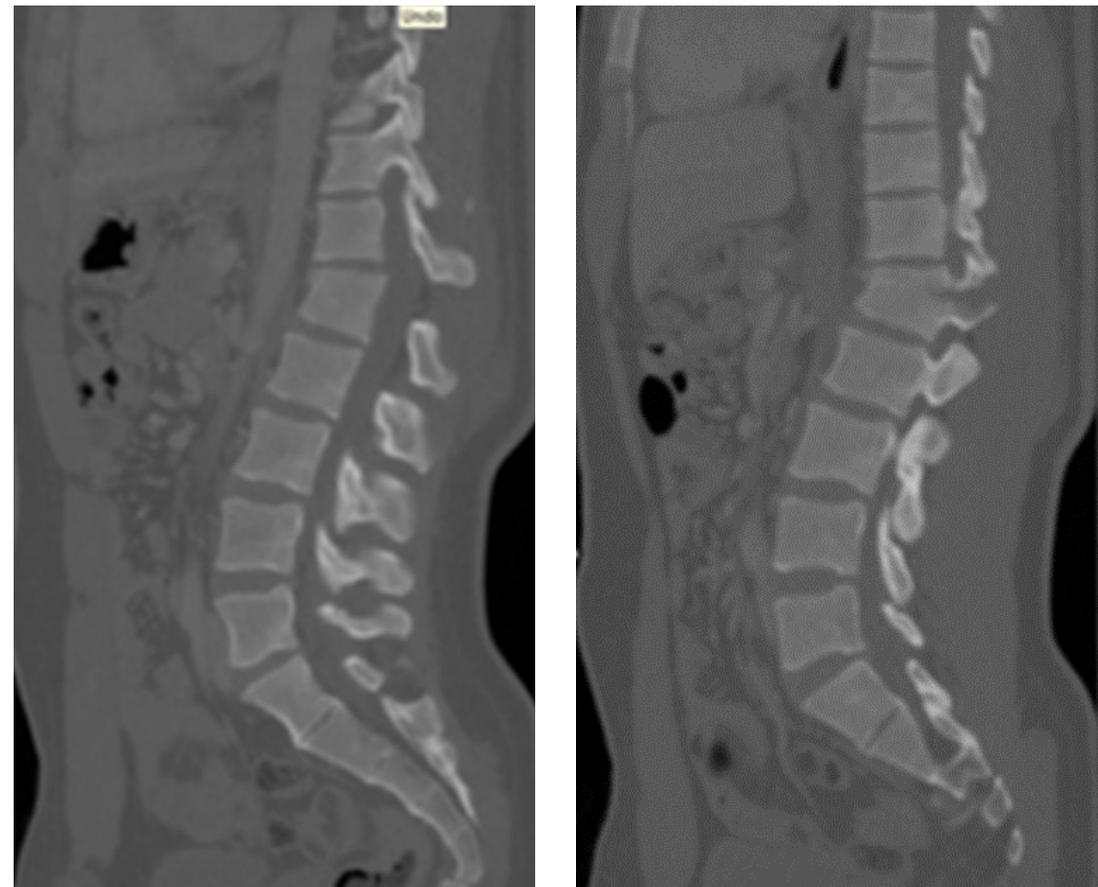
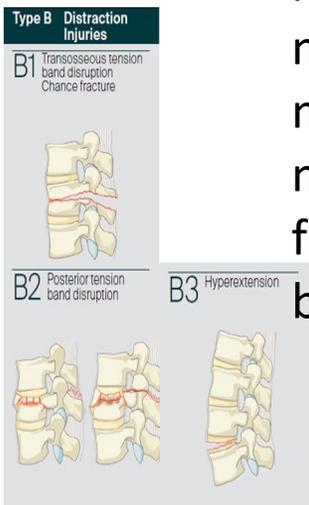


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Core Curriculum V5

## What is the significance of the level of injury in this case?

T12/L1 is junctional – a threshold between the stiff thoracic spine (reinforced by ribs and sternum) and the more mobile lumbar spine. The thoracic spine is splinted by virtue of the ribs attached to the thoracic vertebrae dorsally and sternum ventrally. It can also move as a long lever in a scenario like this making the junction very vulnerable to high moment of force (torque). Here the magnitude of flexion force caused the PLC to fail with the energy exiting ventrally through bone.



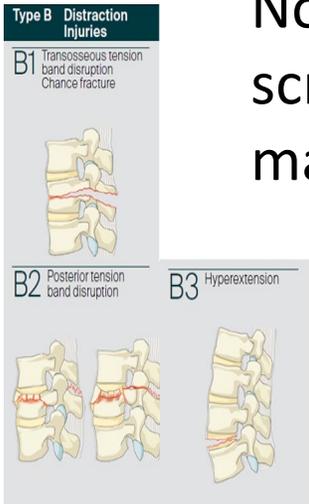
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A pure bony Chance injury (B1) has potential for healing treated non-operatively in extension orthosis, however with ligamentous injury (B2) it requires surgical stabilization.

Note the use of an "index" or "apical" screw on the left L1 pedicle to help maintain lordosis



Orthosis versus no orthosis for the treatment of thoracolumbar burst fractures without neurologic injury: a multicenter prospective randomized equivalence trial. Christopher S. Bailey, Jennifer C. Urquhart, Marcel F. Dvorak, Melissa Nadeau, Michael C. Boyd, Ken C. Thomas, Brian K. Kwon, Kevin R. Gurr, Stewart I. Bailey, Charles G. Fisher. *The Spine Journal*. 14:2557–2564. 2014



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Movie animations depicting B2 type injury process

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Traumatic Thoracolumbar Spine Injuries: What the Spine Surgeon Wants to Know. Bharti Khurana, Scott E. Sheehan, Aaron Sodickson, Christopher M. Bono, Mitchel B. Harris.  
RadioGraphics 33:2031-2046. 2013

# Type B Distraction Injuries

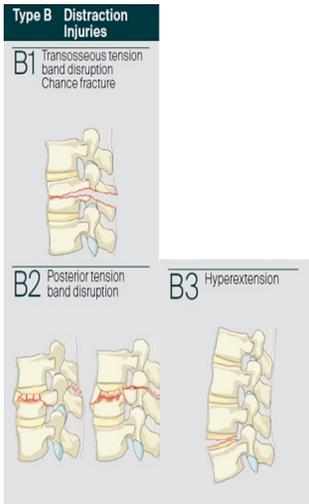
Type B injuries traverse the spinal column and are all considered mechanically unstable (B1-B3) to varying degrees. Beware vascular or viscus injuries at the axis of rotation of these spinal injury types.

*B1 pure bony injuries are unstable but could be considered amenable to non-operative care. For example, a thoracic level B1 fracture would have the added support provided by the ribs and sternum. They require spinal orthosis and regular close observation and radiographic imaging.*

*However many surgeons would advocate for surgical intervention to enable immediate and full mobilization and unimpeded respiration/ventilation, in particular in a polytrauma patient. Also to eliminate the risk of delayed displacement, kyphosis or non-union.*

B2 injuries, having a significant ligamentous component, are considered poor candidates for non-operative care.

*B3 are complicated injuries and are often higher energy mechanisms associated with other injuries or with ankylosing spondylitis. As such they are considered operative cases.*



Orthosis versus no orthosis for the treatment of thoracolumbar burst fractures without neurologic injury: a multicenter prospective randomized equivalence trial. Christopher S. Bailey, Jennifer C. Urquhart, Marcel F. Dvorak, Melissa Nadeau, Michael C. Boyd, Ken C. Thomas, Brian K. Kwon, Kevin R. Gurr, Stewart I. Bailey, Charles G. Fisher. *The Spine Journal*. 14:2557–2564. 2014

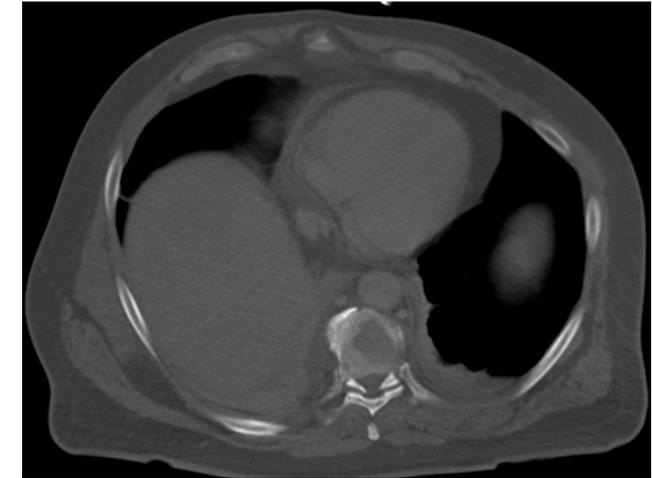
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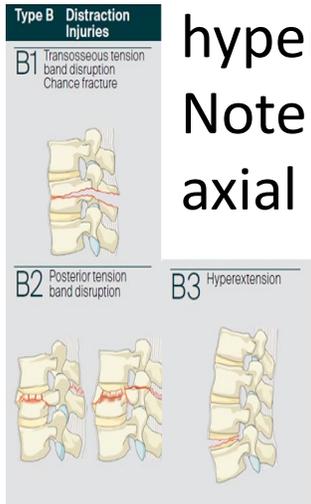
## B3 Type

Case 7: 53 year old male, quad bike accident while working on farm. Sternum and multiple rib fractures, pulmonary contusion, neurologically intact. T9 B3.N0

Radiological features of underlying hyperostotic rigid spine such as DISH. Note the widened facet joints on the axial CT image



Clinical case and images courtesy of Keith Synnott, MD



Injuries to the Rigid Spine: What the Spine Surgeon Wants to Know. Nandish G. Shah, Abhishek Keraliya, Diego B. Nunez, Andrew Schoenfeld, Mitchel B. Harris, Christopher M. Bono, Bharti Khurana. RadioGraphics; 39:449–466. 2019



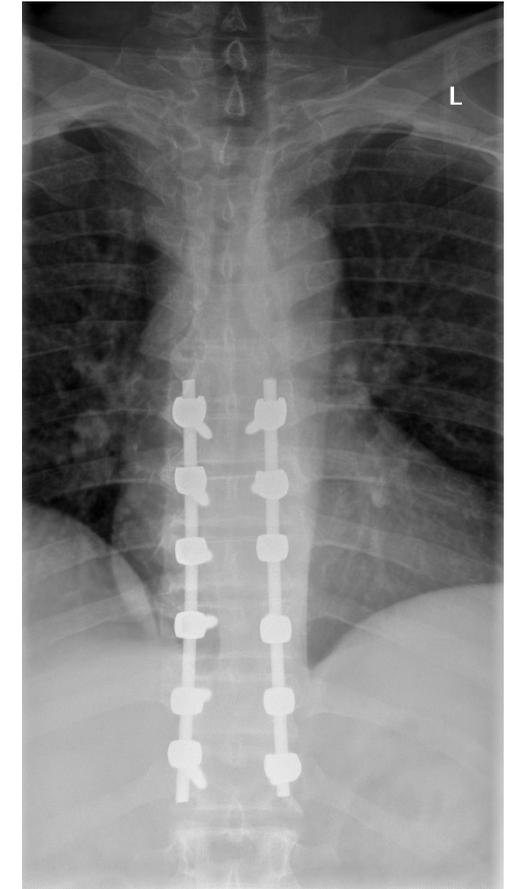
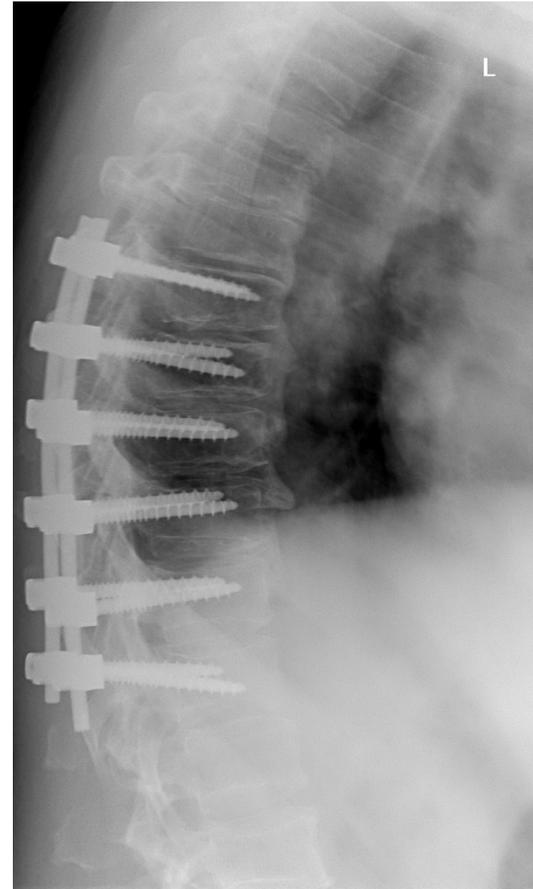
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## B3 Type

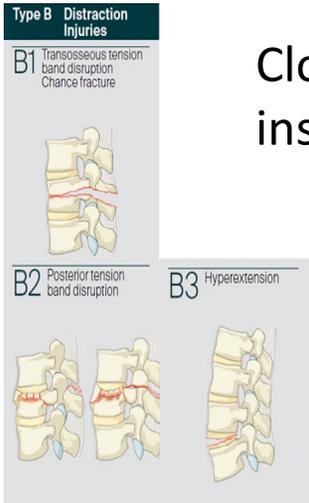
Extra caution with positioning the patient for CT and for general anesthesia (covered in more detail below)

“Sandwich and flip” OR position technique, with extra care and padding for the torso to protect chest due to thoracic wall injuries.

Closed reduction and percutaneous instrumentation technique used

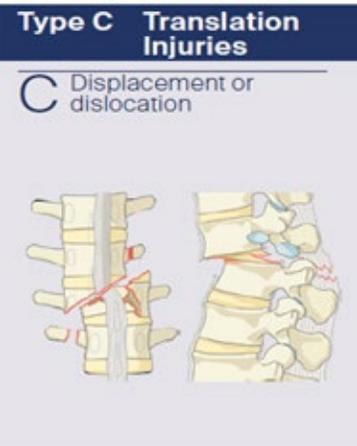


Clinical case and images courtesy of Keith Synnott, MD



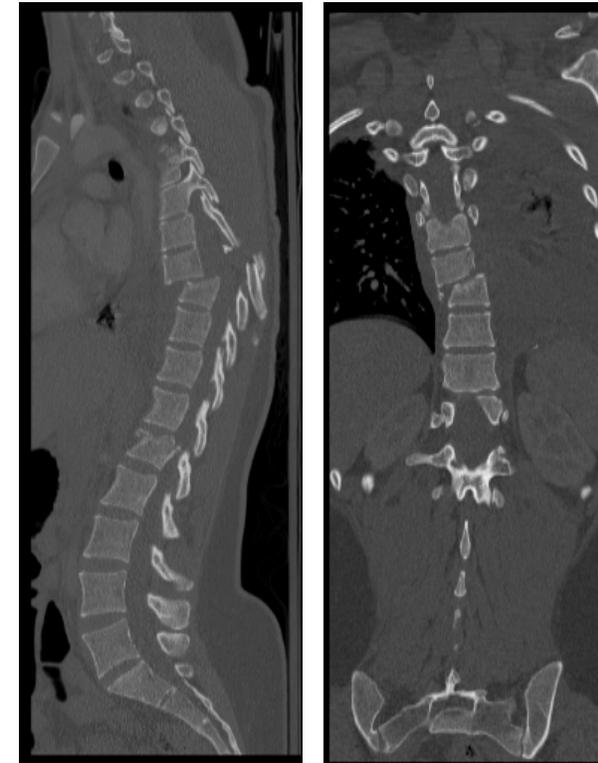
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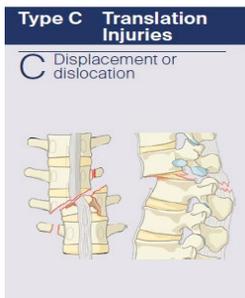


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Case 1 presented above is an example of a C Type injury. These are high energy injuries characteristically associated with often severe chest and abdominal injuries. Unlike in this case example, the likelihood of neurological injury in C Type injuries is very high. Their management follows polytrauma principles with a view to spinal surgery as soon as safe and feasible, and aligned with other interventions and intensive care. Early appropriate spine surgery, whether in the setting of neurological injury or not, does confer an outcome benefit to the patient. Patient transfer and positioning in the OR requires great care and thought. The use of a “sandwich-and-flip” table technique is recommended by the authors of this presentation for **all** spine trauma surgery operative cases.



Clinical case and images courtesy of Jeremie Larouche, MD



A Randomized Controlled Trial of Early versus Late Surgical Decompression for Thoracic and Thoracolumbar Spinal Cord Injury in 73 Patients. Ali Haghnegahdar, Reza Behjat et al. Neurotrauma Reports. 1.1.2020

Early fixation of traumatic spinal fractures and the reduction of complications in the absence of neurological injury: a retrospective cohort study from the American College of Surgeons Trauma Quality Improvement Program. Guttman M., Larouche J, Lyons F, Nathens A. J Neurosurg Spine Aug 28;1-10. 2020

Delay in operative stabilization of spine fractures in multitrauma patients without neurologic injuries: effects on outcomes. Hossein Pakzad, Darren M. Roffey, Heather Knight, Simon Dagenais, Jean-Denis Yelle, Eugene K. Wai. Can J Surg. 54(4): 270–276. 2011

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# Polytrauma

- Multiteam, organised and integrated approach from the get go
- Adherence to Advanced Trauma Life Support ©
- Transfer from spinal board and examine occiput, spine, posterior chest and abdominal wall, flanks and rectum with structured team logroll **as soon as safe to do so**
- Continuous total protection OR complete clearance OR definitive stabilization are the **only** allowable options
- Establish and document neurological status → re-appraise regularly and **always** after transfer, intervention or change in status

- Neurological deterioration after initial assessment in trauma bay, after OR or transfer to ICU is well reported → assume nothing, protect, re-check systematically

ASIA INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY (ISNCSCI) (ISNCSCI)

Patient Name \_\_\_\_\_ Date/Time of Exam \_\_\_\_\_  
 Examiner Name \_\_\_\_\_ Signature \_\_\_\_\_

**RIGHT** MOTOR KEY MUSCLES: UER (Upper Extremity Right), LER (Lower Extremity Right), (VAC) Voluntary Anal Contraction (Yes/No)

**SENSORY** KEY SENSORY POINTS: Light Touch (LTR), Pin Prick (PPR)

**LEFT** MOTOR KEY MUSCLES: UEL (Upper Extremity Left), LEL (Lower Extremity Left), (DAP) Deep Anal Pressure (Yes/No)

**SENSORY** KEY SENSORY POINTS: Light Touch (LTL), Pin Prick (PPL)

Comments (Non-Key Muscle? Reason for NT? Pain? Non-SCI condition?):

Neurological Levels: 1. SENSORY, 2. MOTOR

3. NEUROLOGICAL LEVEL OF INJURY (NLI) \_\_\_\_\_

4. COMPLETE OR INCOMPLETE? Incomplete = Any sensory or motor function in S4-5

5. ASIA IMPAIRMENT SCALE (AIS) \_\_\_\_\_

6. ZONE OF PARTIAL SENSORY PRESERVATION (Most caudal levels with any innervation)

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- This may be from initially normal to evolving paralysis; or from incomplete neurological impairment to complete or worsened state

- Multiple, discontinuous spine fractures in up to 19% of polytrauma patients
  - Whether neurological injury present, not present, or not examinable, the patients' best outcome results from holistic, combined resuscitation, timely stabilisation of fractures and decompression of neural elements
- Mean Arterial Pressure (MAP) targets for neurological injury: lacks high level evidence and may be dangerous in polytrauma
- Decompression: evidence to support early (<24 hours) in setting of traumatic thoracolumbar neurological injury
- Fracture stabilisation: even in absence of neurological injury, improved outcomes if spine definitively fixed early in line with long bone and pelvic fractures

Evaluation of the risk of noncontiguous fractures of the spine in blunt trauma. Nelson, Daniel William DO; Martin, Matthew J. MD; Martin, Niels D. MD; Beekley, Alec MD. J Trauma Acute Care Surg: 2013(75)1:135-139

Current practices and goals for mean arterial pressure and spinal cord perfusion pressure in acute traumatic spinal cord injury: Defining the gaps in knowledge. Menacho ST, Floyd C. Journal Spinal Cord Med. 2019:1-7

A Randomized Controlled Trial of Early versus Late Surgical Decompression for Thoracic and Thoracolumbar Spinal Cord Injury in 73 Patients. Ali Haghnegahdar, Reza Behjat et al. Neurotrauma Reports. 1.1.2020

Early fixation of traumatic spinal fractures and the reduction of complications in the absence of neurological injury: a retrospective cohort study from the American College of Surgeons Trauma Quality Improvement Program. Guttman M., Larouche J, Lyons F, Nathens A. J Neurosurg Spine Aug 28;1-10. 2020





Case 8: 16 year old male, roll over by farm machinery.

Air transfer from scene but no cardiac output on arrival.

ATLS principles followed along with massive transfusion protocol and active re-warming.

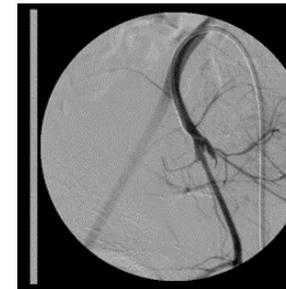
Spontaneous circulation resumed but fully established **lethal triad of trauma**: pH 7.04, lactate 11.0, temperature 33.8°C, INR 3.0. Active pelvic bleeding was treated by **angioembolisation** and the patient returned to the ICU to continue re-warming and resuscitation.



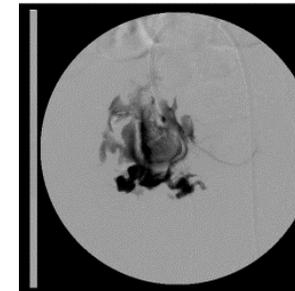
Large ascending retroperitoneal haematoma secondary to pelvic lateral compression injury



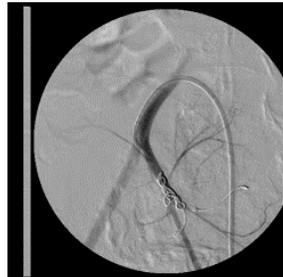
Truncated branch right internal iliac artery



Profuse contrast blush signifies active bleeding

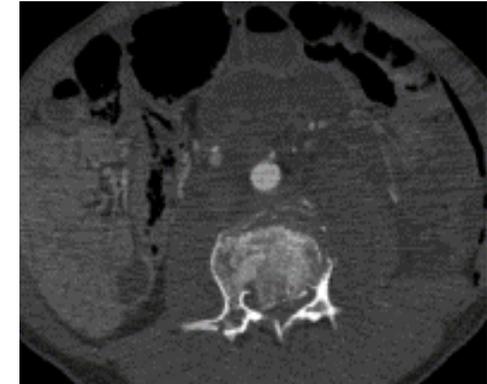
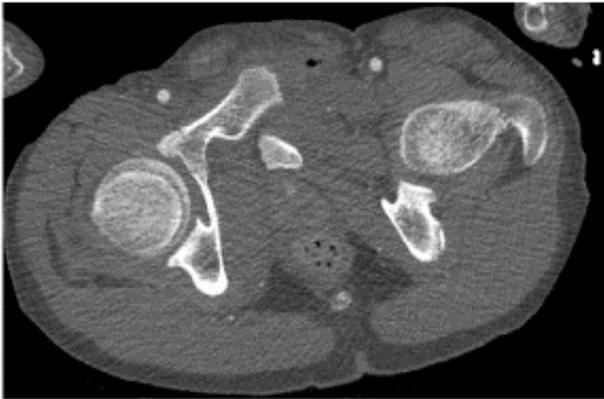


Coiling to control hemorrhage



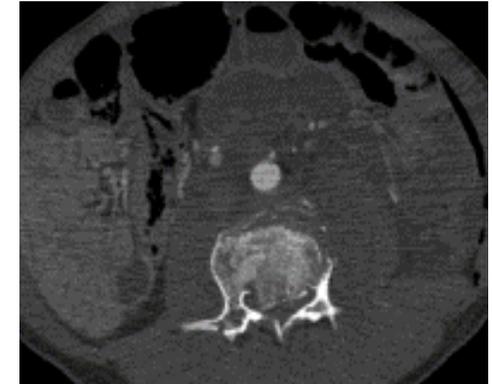
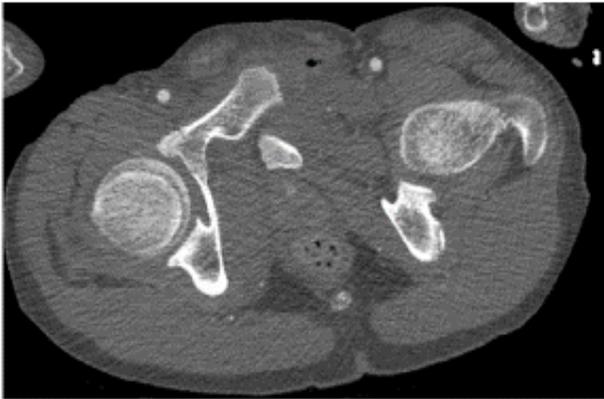
After embolization he had an up/down course but overall improved slowly with re-warming and targeted blood and coagulation product replacement. CT imaging had also revealed massive disruption to the bony pelvis, chest wall and a spinal fracture L3.A3.NX with significant retropulsion in the spinal canal.

How would you approach this young patient if his metabolic and physiological parameters continued to:  
**Improve? Deteriorate? Plateau?**



He clearly needs further surgery – knowing that is the easy bit!!

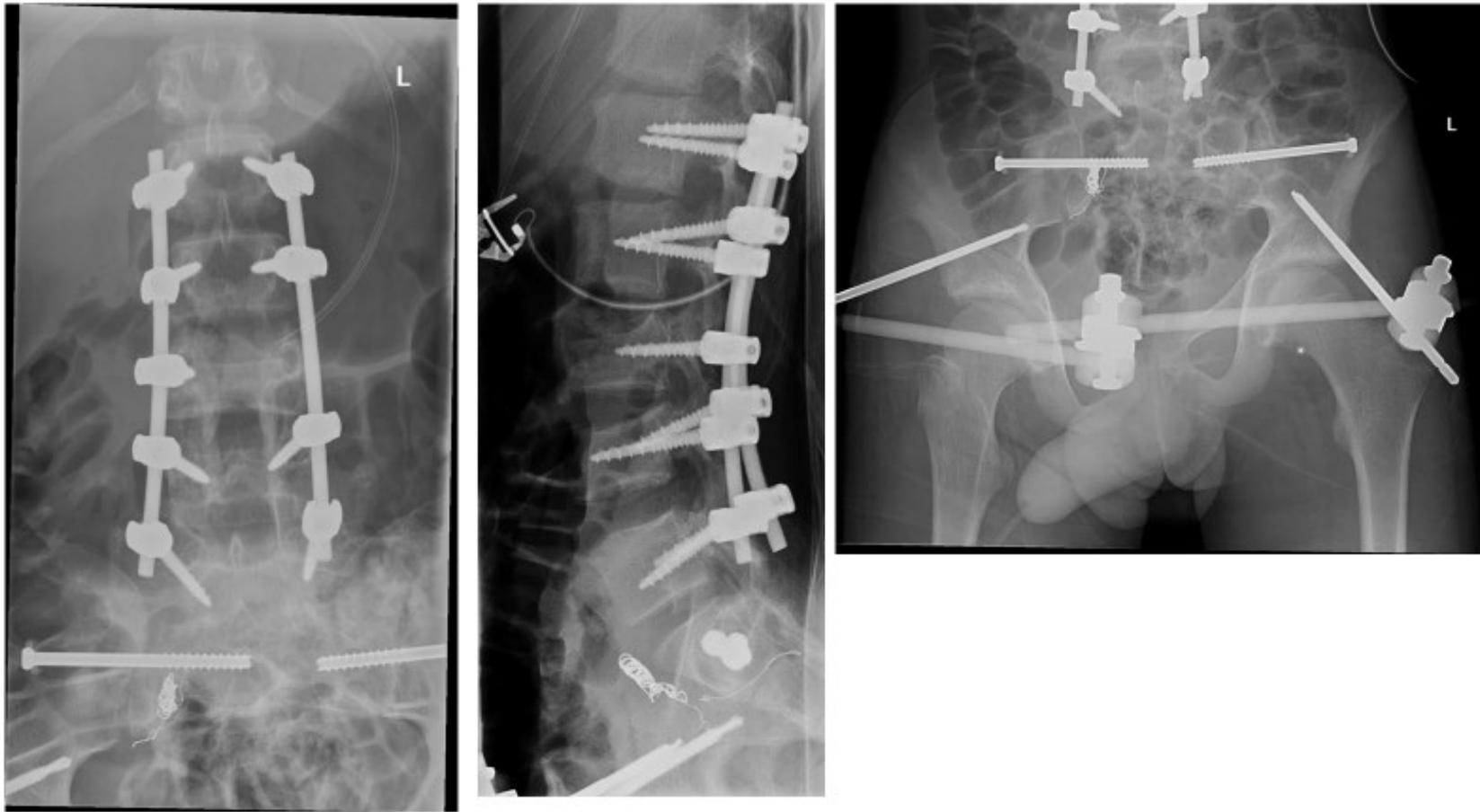
- 1) When?
- 2) In what order?
- 3) Consecutively, simultaneously or separate ORs?
- 4) What parameters safely enable our decisions, and also tell us if we may need to revise those decisions?
- 5) Who are friends with whom we share decision making?
- 6) Rib fixation?



- 1) 54 hours post-injury, but only after aggressive ICU measures achieved an INR 1.6 and lactate 2.8. Consensus decision to proceed to OR
- 2) “Life before limb”:- pelvis first to further to arrest residual venous bleeding and consolidate resuscitation. If stable follow with spine to stabilise and decompress neural elements
- 3) Consecutively, if stable. Simultaneous can be considered in the right circumstances
- 4) Physiologic and metabolic markers
- 5) Trauma critical care and anaesthesia
- 6) Progressing well with low pressure ventilation so combined decision to withhold, also it was increasingly difficult to maintain core temperature  $>35^{\circ}\text{C}$  intraoperatively

Integrated, **coordinated**, **TEAMWORK**





Percutaneous pelvic stabilisation immediately followed by lumbar single level open decompression and multi-level percutaneous stabilisation was carried out. Note coil in branch of right internal iliac artery.

The patient maintained an upward trajectory and was discharged from ICU 5 days later with no neurological impairment.

# Ankylosing spondylitis

- Ankylosing spondylitis is in particular a super high risk group....
- But consider all **rigid spine entities**: ankylosing spondylitis (AS), diffuse idiopathic skeletal hyperostosis (DISH), degenerative spondylosis, and the surgically fused spine
- Stiff, brittle spine: **low energy trauma** often catastrophic - even a standing height fall sufficient to cause unstable injury
- Hyperextension injury mechanism common (B3)
- Patient cohort frequently physiologically frail and comorbidities common

Spine fractures in patients with ankylosing spinal disorders. Caron T, Bransford R, Nguyen Q, Agel J, Chapman J, Bellabarba C. Spine (Phila Pa 1976) 35:E458–E464.2010

Injuries to the Rigid Spine: What the Spine Surgeon Wants to Know. Nandish G. Shah, Abhishek Keraliya, Diego B. Nunez, Andrew Schoenfeld, Mitchel B. Harris, Christopher M. Bono, Bharti Khurana. RadioGraphics; 39:449–466. 2019



- High potential for neurological injury from positioning on CT gantry or ED stretcher
- **Assume unstable** injury until ruled out by higher imaging: **fine cut CT**
- **Low threshold for non-contrast MRI:** epidural hematoma, occult fractures
- Discuss with MSK radiologist if slightest uncertainty with image interpretation - occult and atypical fracture patterns the norm

## FREQUENT DISCONTIGUOUS FRACTURES - IMAGE ENTIRE SPINE

Spine fractures in patients with ankylosing spinal disorders. Caron T, Bransford R, Nguyen Q, Agel J, Chapman J, Bellabarba C. Spine (Phila Pa 1976) 35:E458–E464.2010

Injuries to the Rigid Spine: What the Spine Surgeon Wants to Know. Nandish G. Shah, Abhishek Keraliya, Diego B. Nunez, Andrew Schoenfeld, Mitchel B. Harris, Christopher M. Bono, Bharti Khurana. RadioGraphics; 39:449–466. 2019



Why do we use these warning cards in our ED?



# Ankylosing Spondylitis Patient

Immobilise in position of comfort -  
Avoid altering posture or lying flat -  
Secure with +++pillows, tape and straps -  
CT in current position and notify spine

Why do we use these warning cards in our ED?



Ankylosing spondylitis patients develop a classical stiff, brittle thoracic kyphosis – compared to a normal spine it is noticeably deformed, it is however *their* normal.

Attempting to lie these patients flat for CT or to fit on a spinal board can cause devastating and irreversible neurological injury.

- Immoblilise in position of comfort -
- Avoid altering posture or lying flat -
- Secure with +++pillows, tape and straps -
- CT in current position and notify spine

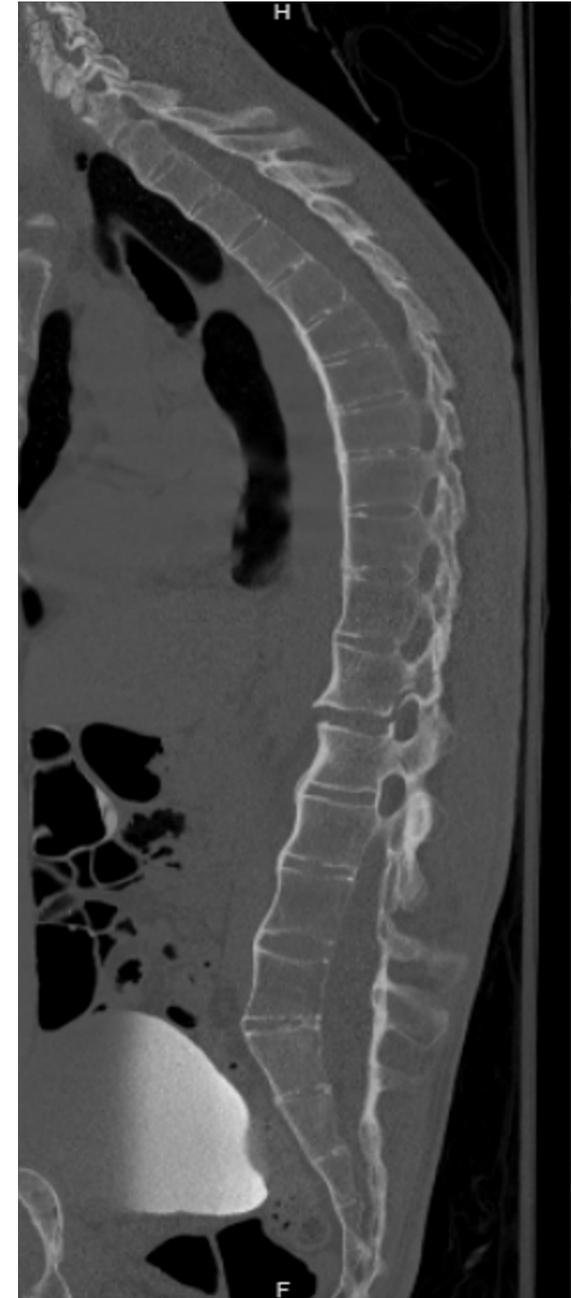
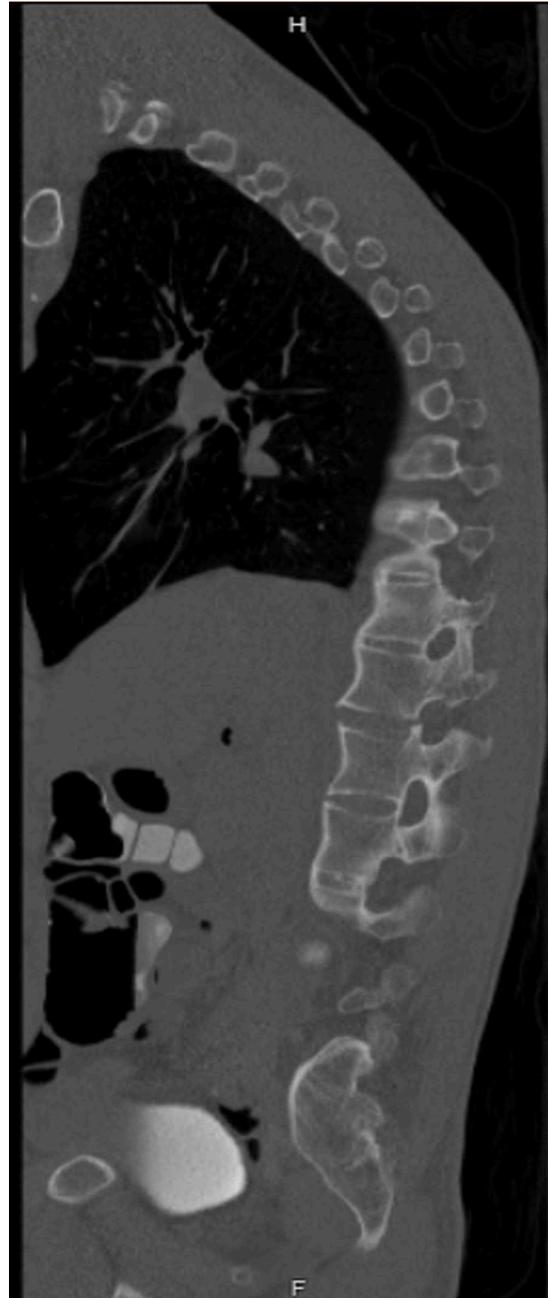
Image courtesy of Gerard O'Connor, MD; Ferdia Bolster, MD and Frank Lyons, MD

Case 9: 64 year old male, fall from bottom step

Localised thoracolumbar pain, third presentation to ED since fall in 6 days with worsening pain. Neurologically normal but non-ambulatory due to pain. Reassured and discharged twice with “nothing concerning seen on x-ray”.

On third presentation the patient was investigated with CT. Have a look at these para mid-sagittal 0.625mm CT slices - can you see the subtle, but very unstable fracture? Also note the patient’s native kyphosis.

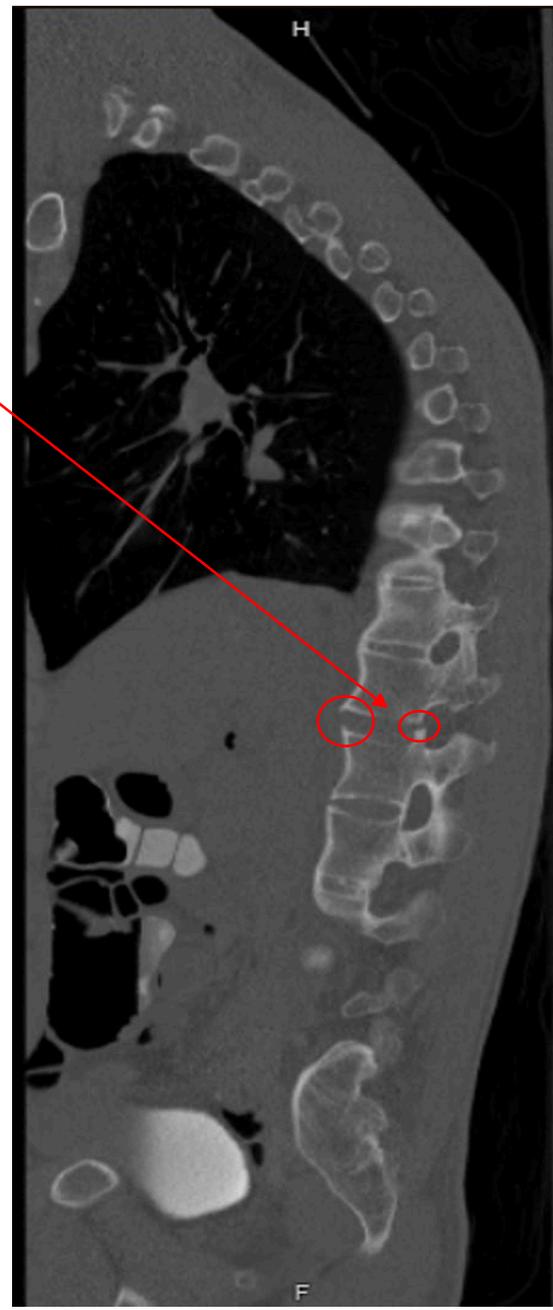
It is tempting, but fruitless, to be critical in retrospect however how would you have managed this patient from the outset?





Fractured anterior and posterior syndesmophytes, passing through the brittle, calcified disc space

Fracture extending posteriorly through pedicle and lamina



14 day post-op

# Osteoporosis

- Characterised by decreased bone mass and inferior microarchitecture
- Not just elderly, any age with low vitamin D, history of corticosteroid use, malignancy, cachexia, or genetic alterations are at risk
- Low energy injuries can result in fracture
- Typically, but not always, mechanically and neurologically **stable**
- Can have deleterious physiological and respiratory impact
- History - pain preceding event may suggest **occult malignancy**
- Mechanism – low energy/standing height fall vs. higher energy e.g. fall down stairs
- Physical exam including documented neurological assessment
- Vigilance for **elder abuse/neglect**
- Evaluate with standing radiographs, follow in fracture clinic and engage **physical therapy early**
- Higher imaging – resource dependent, but low threshold if any concern

Worldwide prevalence and incidence of osteoporotic vertebral fractures. G. Ballane, J. A. Cauley, M. M. Luckey, G. El-Hajj Fuleihan. Osteoporos Int. 28:1531–1542. 2017

Mind the (treatment) gap: a global perspective on current and future strategies for prevention of fragility fractures. Nicholas C.W. Harvey, Eugene V. McCloskey, Paul J. Mitchell, Bess Dawson-Hughes, Dominique D. Pierroz, Jean-Yves Reginster, René Rizzoli, Cyrus Cooper, John A. Kanis. Osteoporos Int. 28(5): 1507–1529. 2017



- Delayed kyphosis, sometimes with neural element compression can evolve
- In particular if occult ligament compromise from index event compounded by suboptimal healing of osteoporotic bone
- Evidence regarding the use of **functional orthoses** is conflicting – an individual tailored approach to each patient is best.
- Cautions for use: muscle deconditioning, respiratory inhibition and a false sense of security

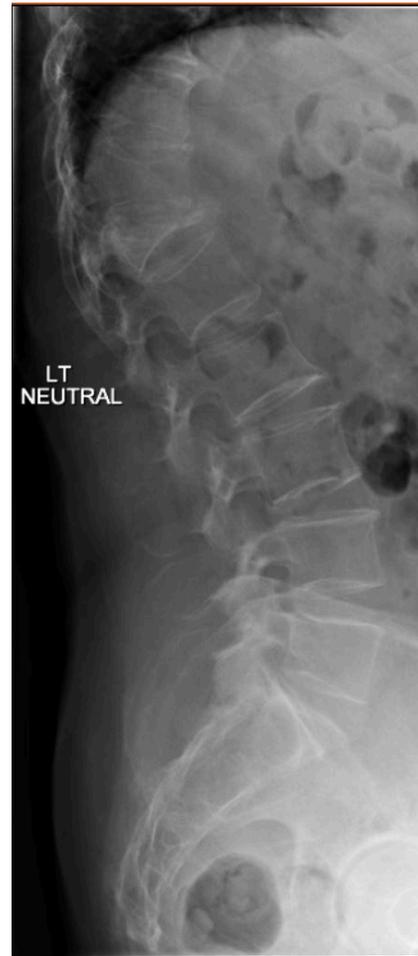
The Role of Spinal Orthoses in Osteoporotic Vertebral Fractures of the Elderly Population (Age 60 Years or Older): Systematic Review. Barry Ting Sheen Kweh, Hui Qing Lee, Terence Tan, Joost Rutges, Travis Marion, Kim Siong Tew, Vikram Bhalla, Shyaman Menon, Fetullah Cumhur Oner, Charles Fisher, Jin Wee Tee. Global Spine Journal. September 2020

Orthosis in Thoracolumbar Fractures – A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Daniela Linhares, Bernardo Sousa Pinto, Manuel Ribeiro da Silva, Nuno Neves, João A Fonseca. Spine (Phila Pa 1976) 2020 Aug 26



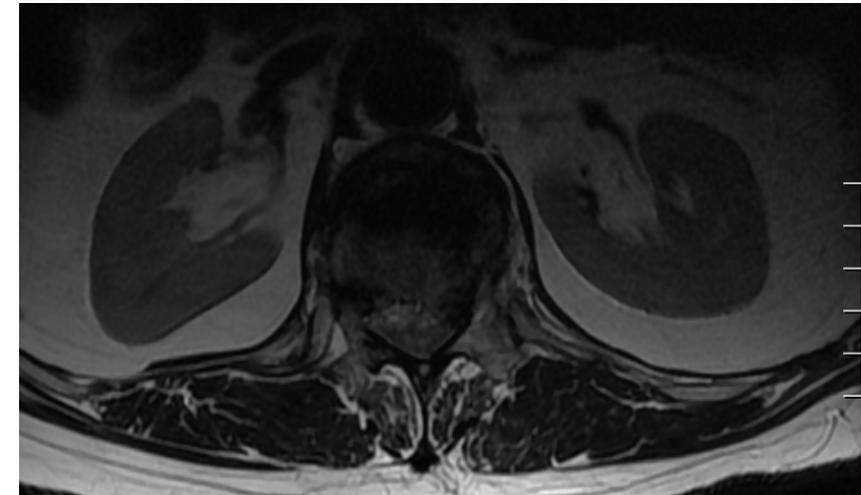
Case 10: 67 year old active female  
Trip and fall down 2 steps. She was initially neurologically intact (N0) and complaining only of localized thoracolumbar back pain.

She has a known T-score of -2.3. What can be deduced from the index lateral standing radiograph shown? A2.N0 fracture noted. No CT imaging was taken, and the patient was fitted with an extension orthosis and referred for follow up in fracture clinic.



Clinical case and images courtesy of Jeremie Larouche, MD

After 4 months she was finding it more difficult to ambulate due to pain and a sensation of being more “bent forward”. A CT was arranged in fracture clinic. She was also developing new bilateral radiculopathy and paresthesia in her lower extremities and so an MRI was carried out.



Clinical case and images courtesy of Jeremie Larouche, MD

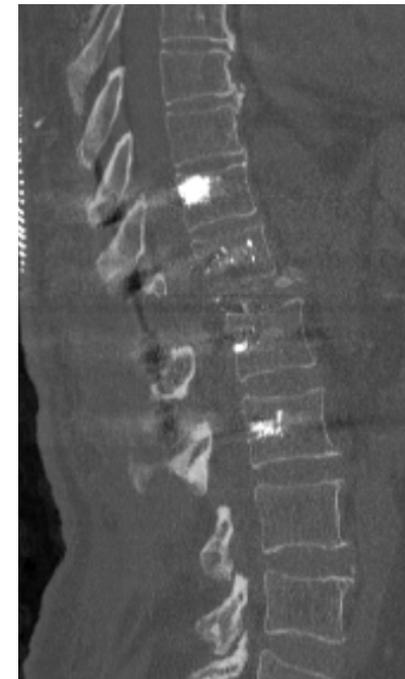
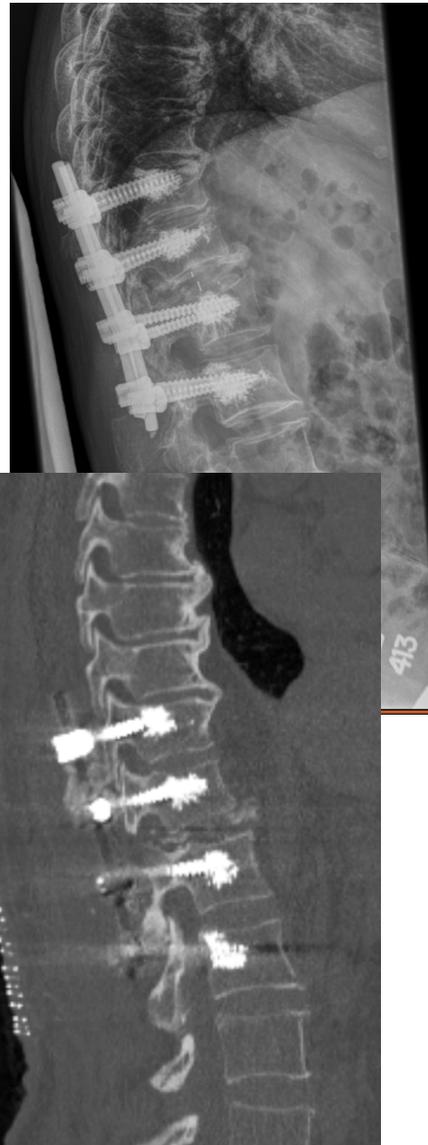
Progressive collapse of the vertebral body due to the fracture and underlying pathological bone (osteoporosis).

The posterior ligamentous complex is subjected to supranormal stress, causing lengthening (strain).

As such, under physiological load, the spine falls into kyphosis.

Treated with vertebral column resection (VCR) of the collapsed T12 and augmented with screw fixation from T10 to L2. The screws have fenestrations for PMMA cement - this can be selectively used for pathological bone as a mechanical augment.

The biomechanics of pedicle screw augmentation with cement. Benjamin D. Elder, Sheng-Fu L. Lo, Christina Holmes, Courtney R. Goodwin, Thomas A. Kosztowski, Ioan A. Lina, John E. Locke, Timothy F. Witham. The Spine Journal 15(6)1432-1445. 2015



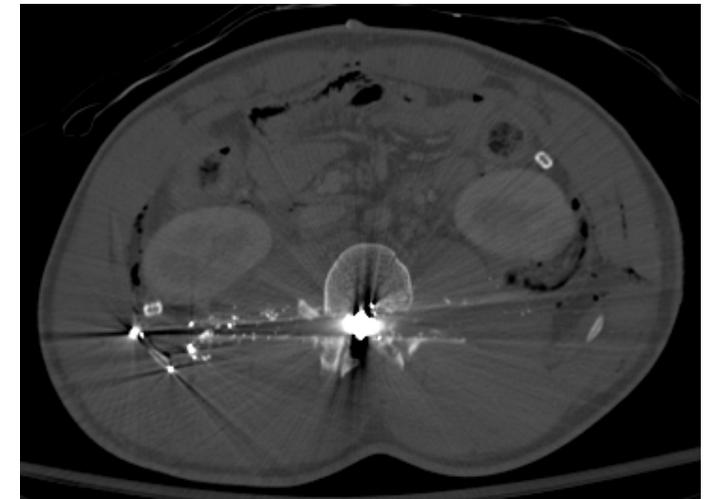
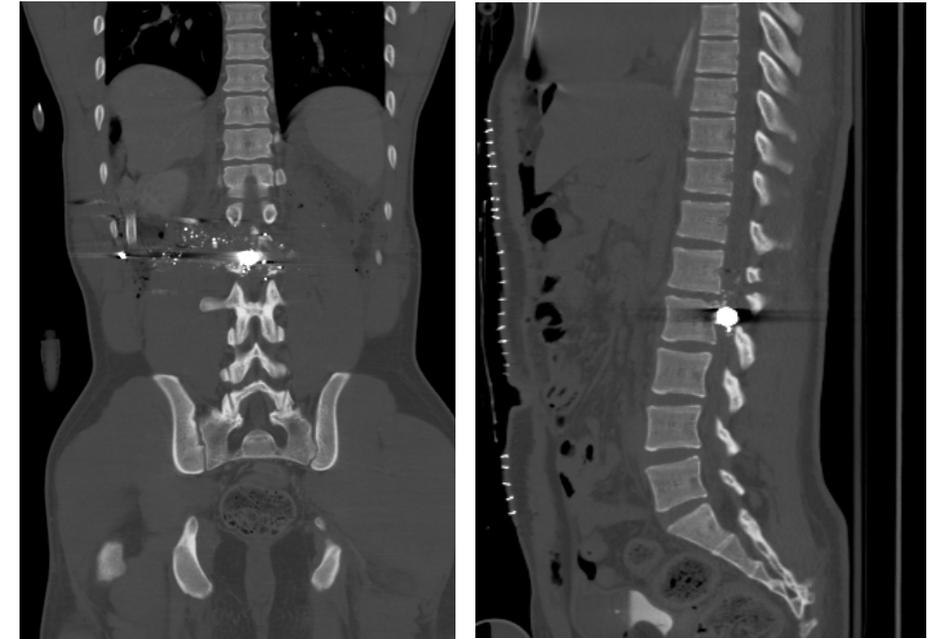
Clinical case and images courtesy of Jeremie Larouche, MD

# Penetrating spinal injuries

- In Military and civilian settings, the victims are usually younger (aged < 30 years) with massive human, societal and economic implications.
- Gun shot or shrapnel high association with major visceral, organ and/or vascular injury.
- Civilian firearms lower powered with the spine injury resulting from direct mass effect.
- Military weapons, which have an added pressure wave and blast effect, are more likely to result in more severe neurologic (and other) injury.
- Military powered weapons increasingly found in civilian settings.

Case 11: 19 year old male, civilian gunshot injury to right flank

- Arrived to ED in extremis and underwent immediate trauma laparotomy.
- After responding to resuscitative interventions and with physiological stabilization achieved, CT imaging was performed.



Clinical case and images courtesy of Joel Finkelstein, MD

-> Resuscitation best with (C)ABC – patients often physiologically unstable

-> Imaging - 3D (CT) or orthogonal radiographs

-> Pathway of bullet may bring bowel contents into spine

-> **Tetanus prophylaxis and ABX for 7-14 days** considered key interventions

- Surgery to spine is controversial:

- > absolute indication with mechanical instability or persistent fistula

- > Relative indication with incomplete cauda equina or evolving neurology

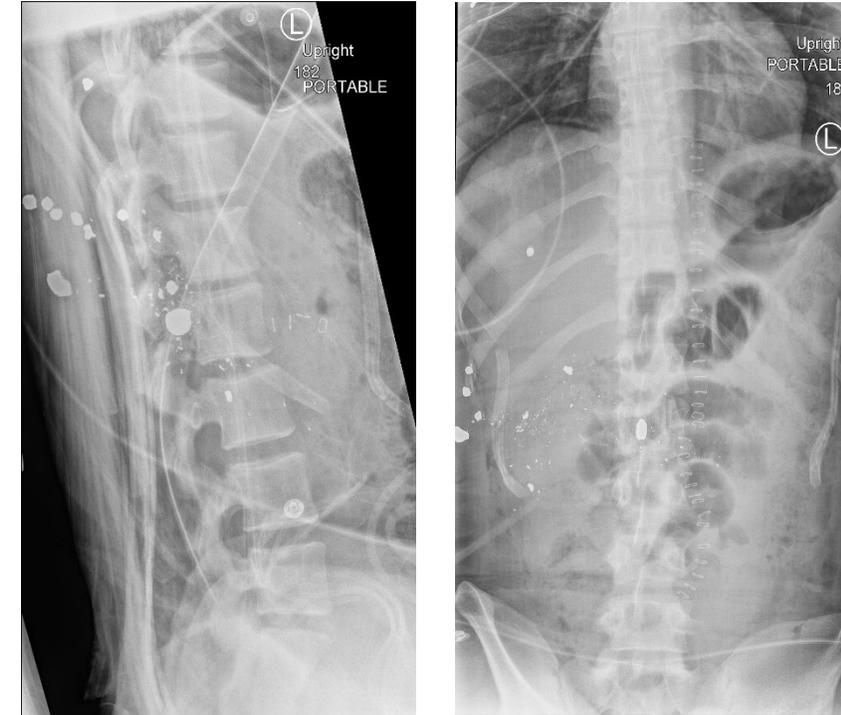
- Decompressive laminectomy generally sufficient – not necessary to “chase” the projectile

- Surgery fraught with complications and results variable

- Lead toxicity rare and only reported from spine if bullet lodged in facet joint or disc

- Removing bullet does not improve long term pain: treat with neuropathic medications

The patient had a complete conus medularis level injury. Sitting upright radiographs demonstrated mechanical stability.



Clinical case and images courtesy of Joel Finkelstein, MD

# *Red flag* trauma

Case 12: This 71 yr old male non-smoker presented 4 days following a minor fall with complaint of non-radiating back pain localising at the thoracolumbar junction. The patient was a retired mechanic and experienced periodic episodes of back pain over his working lifetime. However he had no classical red flags (unexplained weight loss, cancer history, night pain, intense pain refractory to rest or recumbency, smoking history, night sweats). He did comment that for 1 to 2 weeks prior to his fall he had noticed a “mild but persistent pain”.



Clinical case and images courtesy of Jeremie Larouche, MD

There is no hard guidelines on when this type of presentation should be investigated further. Examining and talking with the patient and with a close family member present, and with a low threshold for further investigation, MRI was arranged as well as blood and urine analysis were carried out. The MRI demonstrated features consistent with malignancy. Follow-up CT imaging pointed to a lung primary. The patient underwent percutaneous biopsy with instrumentation and vertebroplasty in the same sitting. Biopsy confirmed EGFR receptor positive lung cancer.

The use of and access to higher imaging such as MRI and CT is not an instrument that should be used without having a question to be answered. To have the question we must build the case by careful and thorough history taking and physical exam.

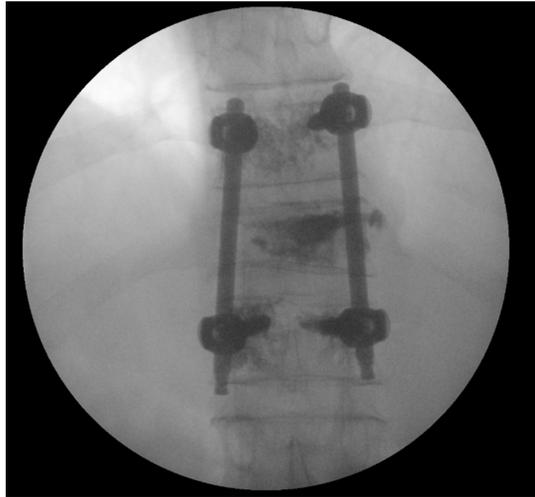


Clinical case and images courtesy of Jeremie Larouche, MD

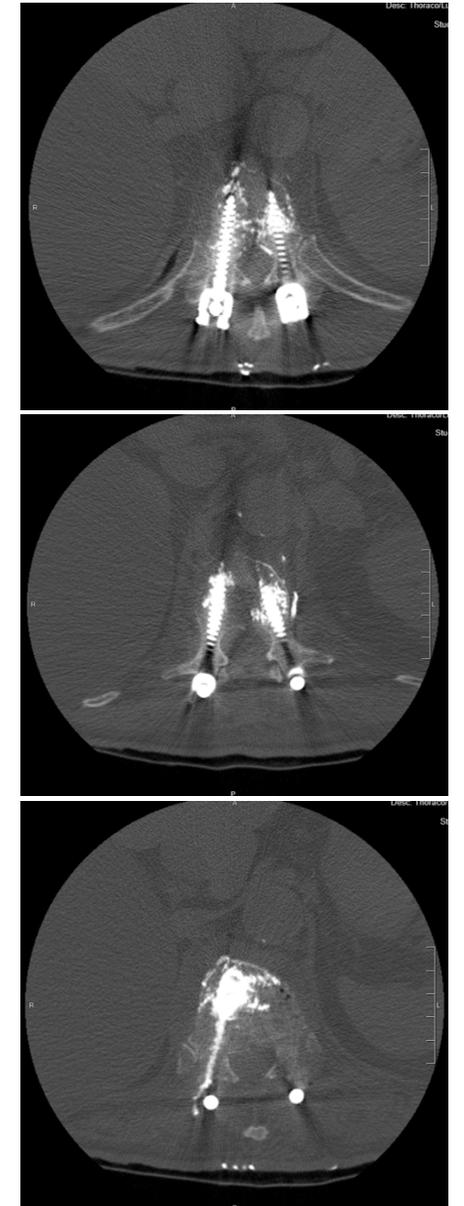
Local practise may vary and imaging thresholds may be influenced not just by clinical factors, but also resource availability.

Local practise may vary and thresholds may be influenced not just by clinical factors, but resource availability too.

In the authors opinion, a low threshold for higher imaging has proven to be the safest approach - but never a substitute for careful history taking and clinical examination.



“Red flags” have a low sensitivity and specificity, i.e. they provide **insufficient clinical guidance** and should not be used in isolation.



Vertebral Metastatic Disease: A Practice Guideline for the General Practitioner. Michael S. Taccone, Markian Pahuta, Darren M. Roffey, Mohammed F. Shamji, Eugene K. Wai. Canadian Spine Society *Spinal Columns* 19(3)40-59. 2019

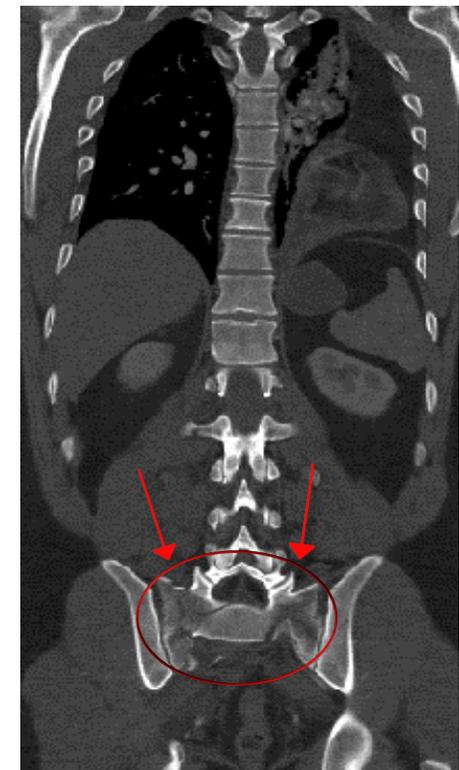
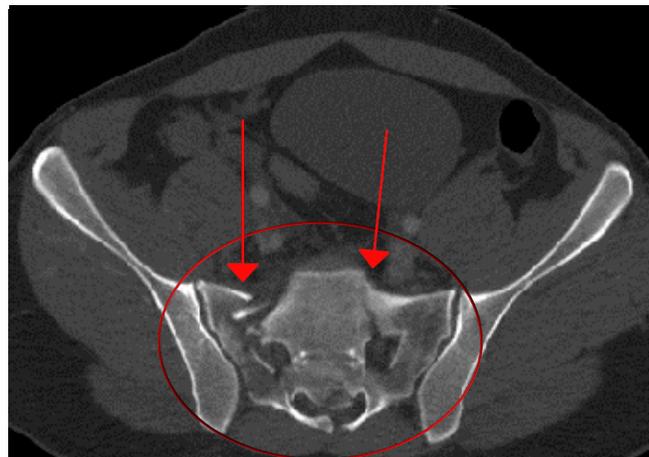
Sensitivity and specificity of patient-entered red flags for lower back pain. Author links open overlay panel. John T. Tsiang, Tyler G. Kinzy, Nicolas Thompson, Joseph E. Tanenbaum, Nitya L. Thakorec, Tagreed Khalaf, Irene L. Katzan. *The Spine Journal* (19)2:293-300. 2019

Clinical case and images courtesy of Jeremie Larouche, MD

# Spinopelvic dissociation

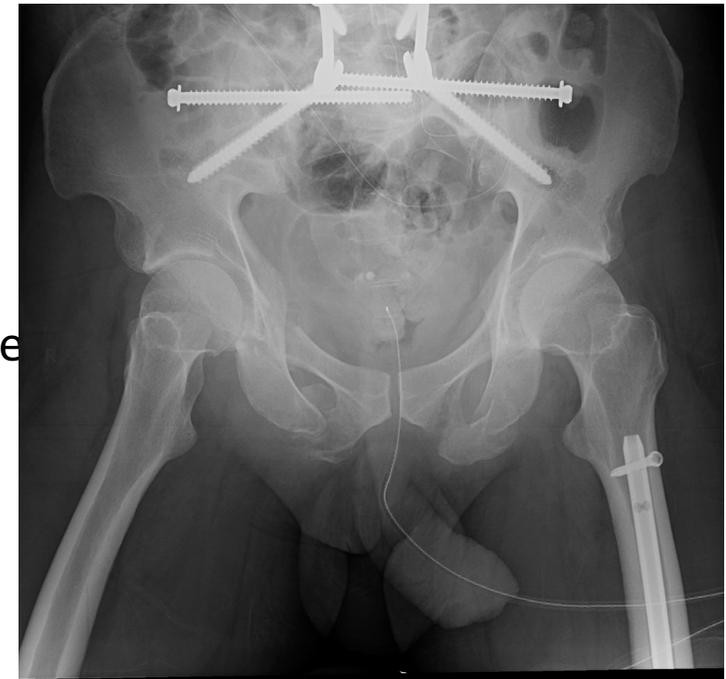
- Typically associated with very high energy such as fall from height; historically termed “*Jumper’s fracture*”.
- Increasing incidence with lower energy frailty and fragility injuries.

Case 13: 34 year old male, high speed motorcycle crash. Multiple severe injuries including chest, abdomen and long bone.

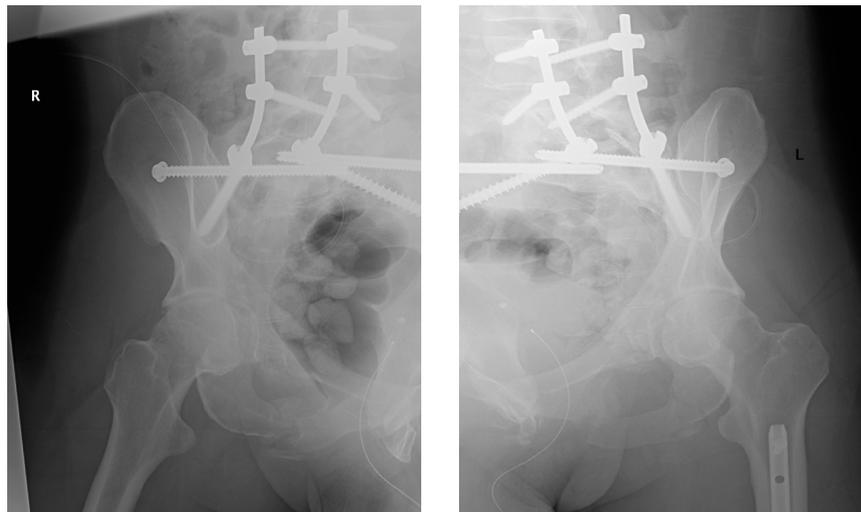
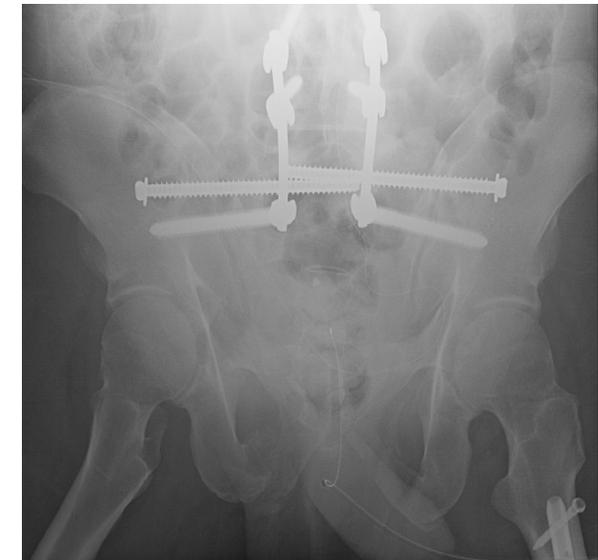


Clinical case and images courtesy of Joseph Butler, MD; Hannah Hughes, MD; and Frank Lyons, MD

- Uncommon injury but must be ruled out in setting of high energy trauma, or low energy trauma in osteoporotic frail patients with a history and clinical findings.
- Association of a transverse sacral fracture with bilateral sagittal plane sacral ala fractures.
- Always look for it to rule out. This especially applicable in the elderly or where osteoporosis apparent. 3D recons or re-orienting 2D axial-coronal-sagittal formatting is helpful.
- Strong association with sacral nerve root injury.
- Open reduction and lumbo-pelvic internal fixation is indicated operative intervention. Selective neural decompression as needed. No role for non-operative except in the most clinically unstable.



Spinopelvic Dissociation: A Retrospective Case Study and Review of Treatment Controversies. Daud Tai Shan Chou, Ibraheim El-Daly, Arun Ranganathan, Alexander Montgomery, Paul Culpan, Peter Bates. JAAOS 26(14)302-312. 2018



Clinical case and images courtesy of Joseph Butler, MD; Frank Lyons, MD and Hannah Hughes, MD

# STOP!

and pause for reflection.

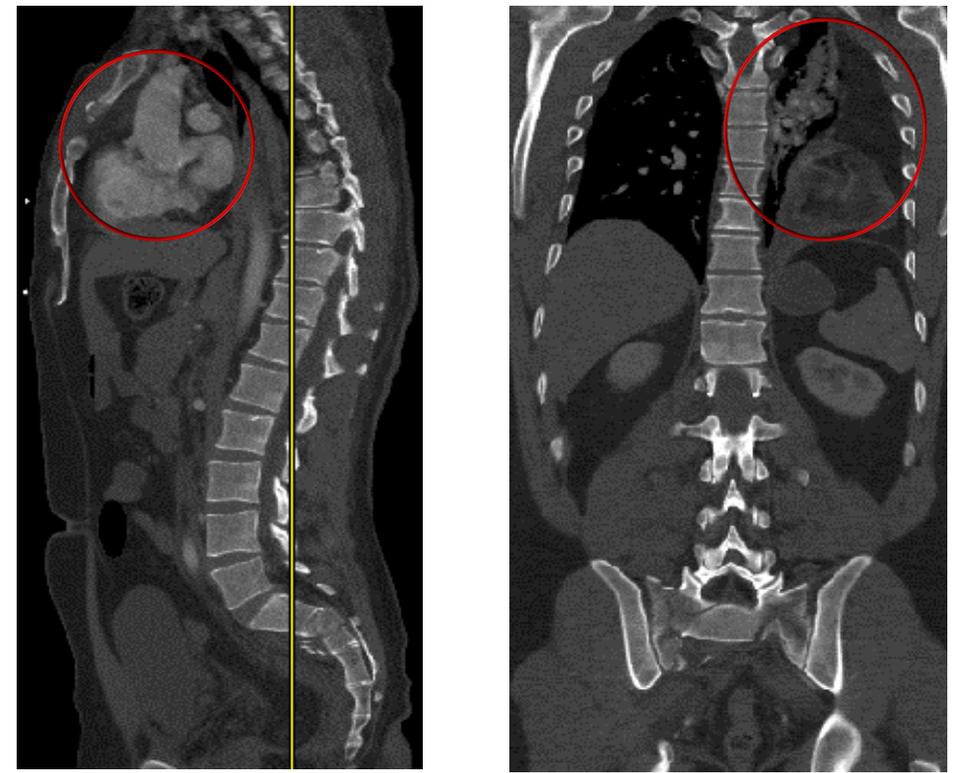
Remember our role is as a part of the whole trauma **TEAM**

Did you notice anything striking on the sagittal and coronal CT?

Look again



- Intrathoracic abdominal viscera secondary to diaphragmatic rupture.
- Our eyes will be drawn towards a narrow field of view.
- Look up and down, left and right. Check twice. Then check again.



Clinical case and images courtesy of Joseph Butler, MD; Hannah Hughes, MD; and Frank Lyons, MD

# Common Complications

- **Blood loss.** Expect lots of it! Operative thoracolumbar spine trauma can exceed **3 litres**
- The “usual treatment” doesn't work...



## Anticipate

- Group and Screen - crossmatch patients ahead of time when possible
- Cell saver
- Tranexamic acid systemically and also topically

## Manage

- Bipolar cautery when near neural elements
- Thrombin products
- Collagen foams and cotton patties

**Infection** presents one of two ways:-

1. Draining, red, angry wound
2. Progressive change in neurological status

In spine trauma surgery the **hardware is essential** to prevent mechanical instability. In the setting of infection it should be left in

Essential to make sure pedicle screws still have purchase, if not -> revise

Rods and endcaps can be exchanged and the wound and screw heads washed out aggressively and thoroughly, and repeatedly. Suppressive antibiotics and involvement of Infectious Diseases or Clinical Microbiology service

**Dural tear** may be iatrogenic occurring during surgery OR may result from the index trauma (especially penetrating or some high energy A, B or C types).

Have a plan and be vigilant for missed tears and delayed or persistent leaks

Persistent headaches, clear fluid from surgical wound, mass or swelling at incision site

Consider if antibiotic cover needed

You can try an LP drain...

You can try bedrest for a few more days...

You can try having interventional radiology perform a blood patch...

Consider re-operation for ongoing leaks...

You should really think about going back to the OR



# Summary

- Active engagement with the broader trauma team from the immediate outset
- Many aspects of trauma management stall in the face of delays around spine clearance, protection and diagnosis
- As soon as safe transfer patient off spinal board, examine and document spine and neurology
- While maintaining full spine precautions prepare for diagnostic imaging – may need to review imaging with radiologist or senior surgeon
- History – Clinical Exam – Imaging => Can you clear this spine? More investigations? or, needs Surgical Stabilisation?
- If clear then it is **fully clear** – remove **all** spinal precautions to allow unimpeded transfer, positioning and mobilisation. Document clearly. Adhere to your **institution policy** for spine clearance and documentation.
- If indeterminate **plan early** for higher level imaging such as MRI, or upright radiographs. **Avoid delay.** If other interventions planned such as laparotomy, guide other teams for safe positioning and transfer maintaining appropriate level of spinal precaution. Be available and hands on.

- Assume nothing, consider **multiple discontinuous spine fractures** and brittle spine disorders
- When spine surgery is deemed necessary plan to do so early
- If impending or established neurological instability then aim for within 24 hours of injury maximally
- In the setting of normal neurology then mechanical stabilisation also within the first 24 hour window aids physiological, respiratory and soft tissue stability and outcome benefit – work with other surgical teams and ICU - **advocate for early spine intervention**
- Specific surgical approach based on **Goals of Surgery** -> mechanical, neurological or other objective
- **Be prepared** – blood products, cell saver, type of anaesthesia (intravenous only if using neuromonitoring), antibiotic prophylaxis, tranexamic acid, navigation, cement augmentation, dural repair adjuncts
- Know and follow your institutions policies and practises
- Large exposure in spine means rapid loss of body heat -> essential in trauma to **prevent hypothermia**
- **Don't be a hero** – early and readily discuss with seniors. Even if you are *the senior*, discuss with colleagues



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