Thoracolumbar and Lumbar Burst Fractures

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Thoracolumbar/Lumbar Burst Fractures: Overview

- Epidemiology
- Anatomy
- Initial Assessment
- Imaging
- Injury Mechanism/Biomechanics
- Fracture Classification
- Treatment Options: Operative vs. Non-operative Management
Epidemiology

- 79,000 spinal fractures in U.S. each year – 72.5% involve thoracic or lumbar spine \cite{1,2}
- Most common site of injury is thoracolumbar junction
  - Mechanical transition zone between rigid thoracic and more mobile lumbar spine \cite{3-5}
- Lumbar spine more prone to injury
  - Absence of ribs, transition from kyphotic to lordotic posture, sagitally oriented facet joints \cite{6}
- Operative versus non-operative mgmt: controversy
Anatomy

- Vertebral column: 29 vertebrae organized in 4 curves:
  - 2 primary curves present at birth: thoracic and sacral (kyphosis)
  - 2 compensatory curves - result of adaptation to upright posture: cervical and lumbar (lordosis)
Anatomy

- **T spine**: made rigid by ribcage articulations (ligamentous support); facet joints in coronal plane limit flexion/extension

- **L spine**: facet joints in sagittal plane increase flexion/extension but decrease lateral bending/rotation

- **TL junction**: facet joints in oblique orientation; provide support and resistance to 35-45% of torsional and shear forces on spine
Initial Assessment

- **ABCs & Immobilization**: patients should be immobilized until stability of fracture can be assessed adequately – avoid loss/worsening of neurological deficits [4]

- **Neurological exam**: performed as soon as the patient is hemodynamically stable: motor, sensation, DTRs, digital rectal exam [10]

- Neurologic deficits from TL fxs can involve spinal cord or cauda equina

- 70% of thoracolumbar injuries do not have associated neurologic deficits [2]
Initial Assessment: Motor Examination

- Upper extremity
  - C5-shoulder abduction
  - C6-wrist extension
  - C7-wrist flexion
  - C8-finger flexion
  - T1-finger abduction
Initial Assessment: Motor Examination

- Lower extremity
  - L1-hip flexion
  - L2-hip adduction
  - L3-knee extension
  - L4-ankle dorsiflexion
  - L5-toe extension
Initial Assessment: Dermatomes

Levels of principal dermatomes

- **C5**: Clavicles
- **C5, 6, 7**: Lateral parts of upper limbs
- **C8, T1**: Medial sides of upper limbs
- **T2**: Thumb
- **C6, 7, 8**: Hand
- **C8**: Ring and little fingers
- **T4**: Level of nipples

Levels of dermatomes

- **T10**: Level of umbilicus
- **T11, 12**: Inguinal or groin regions
- **L1, 2, 3, 4**: Anterior and inner surfaces of lower limbs
- **L4, 5, S1**: Foot
- **L4**: Medial side of great toe
- **S1, 2, L5**: Posterior and outer surfaces of lower limbs
- **S1**: Lateral margin of foot and little toe
- **S2, 3, 4**: Perineum
Initial Assessment: Classification of injury

- American Spinal Injury Association (ASIA)
  - A = Complete – No Sacral Motor / Sensory
  - B = Incomplete – Sacral sensory sparing
  - C = Incomplete – Motor Sparing (<3)
  - D = Incomplete – Motor Sparing (>3)
  - E = Normal Motor & Sensory
STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

MOTOR

KEY MUSCLES

C2  L  
C3  R  
C4  L  
C5  R  
C6  L  
C7  R  
C8  L  
T1  R  
T2  L  
T3  R  
T4  L  
T5  R  
T6  L  
T7  R  
T8  L  
T9  R  
T10  L  
T11  R  
T12  L  
L1  
L2  
L3  
L4  
L5  
S1  
S2  
S3  
S4-5

Elbow flexors
Wrist extensors
Elbow extensors
Finger flexors (distal phalanx of middle finger) C8
Finger abductors (little finger)
Hip flexors
Knee extensors
Ankle dorsiflexors
Long toe extensors
Ankle plantar flexors

Voluntary anal contraction (Yes/No)

0 = total paralysis
1 = palpable or visible contraction
2 = active movement, gravity eliminated
3 = active movement, against gravity
4 = active movement, against some resistance
5 = active movement, against full resistance
NT = not testable

TOTALS □ + □ = □ MOTOR SCORE

(MAXIMUM) (50) (50) (100)

LIGHT TOUCH

TOTALS □ + □ = □ LIGHT TOUCH SCORE

(MAXIMUM) (56) (56)

PIN PRICK

TOTALS □ + □ = □ PIN PRICK SCORE

(MAXIMUM) (56) (56)

SENSORY

KEY SENSORY POINTS

0 = absent
1 = impaired
2 = normal
NT = not testable

Any anal sensation (Yes/No)

S4-5

SENSORY LEVEL

The most caudal segment with normal function

COMPLETE OR INCOMPLETE?

Incomplete = Any sensory or motor function in S4-S5

ZONE OF PARTIAL PRESERVATION

Caudal extent of partially innervated segments

ASIA IMPAIRMENT SCALE

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Imaging: X-Rays

- **AP and lateral:**
  - AP view: pedicles, VBs, disc spaces, spinous processes
  - Lateral view: VB heights, disc space relations, VB alignment, paraspinal swelling
Imaging: X-ray

- In the presence of injury, the entire spine should be imaged to rule out noncontiguous injuries.

- Degree of kyphosis can be measured using Cobb Measurement.
Imaging: CT

- CT yields more diagnostic information than plain radiographs regarding extent of bony injury [6,12]
Imaging: MRI

- MRI allows visualization of soft tissue components of spinal injuries [6]
- Useful at thoraco-lumbar junction due to variable location of conus medullaris
Injury Mechanism/Biomechanics

- Gravity exerts continual axial load on the vertebral column.

- Body’s center of gravity is approx. 4 cm anterior to first sacral vertebra – results in ventral bending vector acting on spinal column.

- **Posterior ligamentous complex** acts as dorsal tension band to counteract these forces - net sum of vectors acting on spine equal zero.

- Essential to prevent change in spine’s sagittal alignment.
Injury Mechanism/Biomechanics

- **PLC**: interspinous ligaments and ligamentum flavum

- Trauma resulting in spinal ligament/osseous structure disruption may change net vector sum acting on spine from zero, resulting in potential for spinal imbalance
Injury Mechanism/Biomechanics

- Whiteside [9]: analogy of construction crane
- Failure of the cable leads to the crane falling forward – in spine, illustrated by characteristic kyphotic deformity seen with unstable burst fxs
Fracture Classification

- Fracture classification allows organization and treatment of fractures through protocols developed to maximize patient outcomes.

- Most classification schemes based on criteria for describing stability.
Fracture Classification: Holdsworth

- Holdsworth\textsuperscript{[15]}: two-column model of spine stability (1960s). Separated spine into anterior weight-bearing column (a) and posterior tension-bearing column (b).
- Burst fractures unstable if PLC is disrupted.
Fracture Classification: Denis

- Denis [3]: three-column classification of spinal fractures (1980s). Injury to middle column was necessary and sufficient to create instability.
- Based classification on results of biomechanical studies demonstrating that isolated rupture of PLC is insufficient to create instability.
## Fracture Classification: Denis

- Divides spinal fractures into minor and major injuries
- Minor injuries: fractures of transverse process, pars interarticularis, spinous process
- Major injuries:

<table>
<thead>
<tr>
<th>Fracture type</th>
<th>Column</th>
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<tbody>
<tr>
<td></td>
<td>Anterior</td>
</tr>
<tr>
<td>Compression</td>
<td>Compression</td>
</tr>
<tr>
<td>Burst</td>
<td>Compression</td>
</tr>
<tr>
<td>Seat-belt type</td>
<td>Intact</td>
</tr>
<tr>
<td>Fracture dislocation</td>
<td>Compression, rotation, shear</td>
</tr>
</tbody>
</table>
Fracture Classification: Denis

- Compression Fracture
- Burst Fracture
Fracture Classification: Denis

- Seat-belt type
- Fracture dislocation
Fracture Classification: Denis

- Denis’ 3 types of instability:
  - Mechanical (1\textsuperscript{st} degree) – may result in late kyphotic deformity. Require external or operative stabilization.
  - Neurologic (2\textsuperscript{nd} degree) – retropulsion of bone fragments predispose patients to increased risk for neurologic injury. Controversy re: operative stabilization.
  - Mechanical/neurologic (3\textsuperscript{rd} degree) – develop after burst fx w/neuro deficit or fracture/dislocation. Highly unstable > require operative decompression and stabilization.
Fracture Classification: McCormack

- **McCormack** [17]: load-sharing classification, designed specifically for thoracolumbar burst fxs (1994)
- Uses point system: grades amount of VB comminution, displacement of fracture fragments, degree of kyphosis (1-9 points)

<table>
<thead>
<tr>
<th>Score</th>
<th>1 point</th>
<th>2 points</th>
<th>3 points</th>
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</thead>
<tbody>
<tr>
<td>Sagittal collapse</td>
<td>30%</td>
<td>&gt;30%</td>
<td>60%</td>
</tr>
<tr>
<td>Shift</td>
<td>1mm</td>
<td>2mm</td>
<td>&gt;2mm</td>
</tr>
<tr>
<td>Correction</td>
<td>3 degrees</td>
<td>9 degrees</td>
<td>10 degrees</td>
</tr>
</tbody>
</table>
Fracture Classification: McCormack

- With McCormack, patients with >6 points have a large void or gap, resulting in least supportive anterior and middle columns and predisposing posterior instrumentation for failure.

- Original goal was to predict failure of short-segment posterior fixation for burst fxs – prescribes that injuries with high scores should undergo supplemental anterior column support.
Fracture Classification: TLICS

- **TLICS system** \(^{[13]}\) designed by the Spine Trauma Study Group (2008). Based on 3 aspects:
  - morphology of the injury
  - integrity of the PLC
  - neurological status of the patient

<table>
<thead>
<tr>
<th>Injury morphology</th>
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<tbody>
<tr>
<td>Compression</td>
<td>1</td>
</tr>
<tr>
<td>Burst</td>
<td>1</td>
</tr>
<tr>
<td>Translation rotation</td>
<td>3</td>
</tr>
<tr>
<td>Distraction</td>
<td>4</td>
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<table>
<thead>
<tr>
<th>PLC integrity</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intact</td>
<td>0</td>
</tr>
<tr>
<td>Indeterminate</td>
<td>2</td>
</tr>
<tr>
<td>Disrupted</td>
<td>3</td>
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<table>
<thead>
<tr>
<th>Neurological status</th>
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<tbody>
<tr>
<td>Intact</td>
<td>0</td>
</tr>
<tr>
<td>Nerve root injury</td>
<td>2</td>
</tr>
<tr>
<td>Complete</td>
<td>2</td>
</tr>
<tr>
<td>Incomplete</td>
<td>3</td>
</tr>
</tbody>
</table>
Fracture Classification: TLICS

- **TLICS determination for surgery:**
  - <3 points can be treated non-operatively
  - >5 points usually require surgical intervention
  - = 4 points can be treated w/or w/o surgery

- **TLICS determination of surgical approach:**
  - Incomplete + anterior compression = ANT
  - Incompetent PLC = POST
  - Neurological deficit + incompetent PLC = ANT + POST
Treatment Options

- Controversy regarding operative vs. non-operative management, surgical approach
- Treatment based on maximizing neurologic recovery and preventing neurologic decline – identify unstable fractures
Non-operative Management

- Most fractures in thoracolumbar/lumbar region consist of compression, burst fractures, and isolated dorsal column fractures – stable fxs
  - Compression fxs: stable if PLC, along with dorsal vertebral body, is not disrupted (Denis) – bracing
  - Burst fxs: stable if no PLC injury/dorsal element fx. Neurologically intact patient > bracing
Non-operative Management

Thoracolumbar Burst Fractures
The Clinical Efficacy and Outcome of Nonoperative Management

Joe Mumford, MD, James N. Weinstein, DO, Kevin F. Spratt, PhD, and Vijay K. Goel, PhD
Mumford et al

- 41 pts with thoraco-lumbar burst fxs w/o neurological deficit treated conservatively
- At injury, canal compromise averaged 37% - at 2 years f/u, 2/3 resolution of fragments occluding canal
- Outcome evaluation: 49% patients reported excellent outcomes relative to pain and function
- Progression of body collapse on imaging averaged 8%
- 1 pt developed neurologic deterioration prompting surgery – all other pts remained neurologically intact
Nonoperative Management of Stable Thoracolumbar Burst Fractures With Early Ambulation and Bracing

Jeffrey B. Cantor, MD, Nathan H. Lebwohl, MD, Timothy Garvey, MD, and Frank J. Eismont, MD
18 neurologically intact patients with burst fxs w/o PLC disruption – treated with early ambulation w/bracing

Kyphosis: 19 degrees at time of injury, 20 degrees at f/u

VB height loss: 36% on presentation, max change 5% at f/u

At f/u 15 pts rated their pain as little or none, 17 pts had little or no restriction of activity.

CT scan 1 yr after injury in 8 pts showed >50% resorption of retropulsed bone

No patient had deterioration of neurological function.
Surgical Treatment

- Surgical Treatment – 3 components:
  - Neural Decompression
  - Stabilization
  - Fusion
Surgical treatment: Decompression

- TL and Lspine fx w/ neuro deficit have significantly higher recovery rate when treated with surgery.
  Primary goal: decompression of the spinal canal [4,7]

- Anterior, compared to posterior and posterolateral decompression has a higher rate of neurologic improvement (88% vs. 64%) and recovery of B&B function (69% vs. 33%). [8,18]

- Anterior decompression via corpectomy: maximal degree of canal decompression

- Treatment of low lumbar (L3-5) burst fx require posterior approach
Surgical treatment: Decompression

- Timing of surgery in patients with burst fx with neurologic deficit is unclear
  - Most clinical studies have shown no correlation between timing and amount of neurologic recovery [7,11]
  - One study (Mirza et al, 1999) showed improved neurologic recovery with surgery within 72 hrs vs. 10-14 days [16]
- Patients with progressive deficit need emergent decompression
Surgical Treatment: Stabilization

- Primary role of surgical instrumentation: restore immediate stability and correct acute deformities

- Anterior stabilization:
  - Advantage: limits fusion to level above and below injury
  - Disadvantage: risk of vascular and visceral injury
Surgical Treatment: Stabilization

- Options for posterior stabilization: rods secured by screws, hooks, or wires
- Pedicle screw system: instrument two levels above and below injury
- Short segment stabilization (one level above and below) has high rate of construct failure. If spinal flexibility is priority, can be combined w/anterior instrumentation [17,19]
Surgical Treatment: Fusion

- Long term goal of instrumentation: maintain proper spinal alignment and stability until bone fusion occurs \cite{9,19}

- Without solid fusion, metallic implants eventually break

- In order for fusion to occur, bone graft or graft replacement must have:
  - Osteogenicity
  - Osteoinductivity
  - Osteoconductivity
**Surgical Treatment: Fusion**

- **Anterior fusion:**
  - Autograft (Iliac crest)
  - Allograft (Femoral or humeral shaft)
  - Synthetic cage

- **Posterior fusion:**
  - Decortication of exposed bone elements
  - Implantation of bone fragment or bone matrix
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