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Evaluation and Treatment of Thoracolumbar Junction Trauma

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Abstract: The thoracolumbar junction is the most common area of injury to the axial skeleton. A wide variety of injury patterns and clinical presentation is encountered in this region, and multiple classification systems have been devised. According to the three-column theory of Denis, injury to the anterior column results in a compression fracture. Injury to both the anterior and middle columns results in a burst fracture with possible retropulsion of bone posteriorly into the spinal canal. Injury to all three columns results in either a flexion distraction injury or a fracture dislocation. Since the spinal cord ends in this region, neurological injuries can result in either a cord or a cauda equina lesion, which vary in their prognoses. Significant controversy exists regarding surgical intervention for these fractures. This paper reviews the general principles of evaluation and treatment of thoracolumbar trauma.

Introduction

Forces along the long stiff kyphotic thoracic spine switch abruptly into the mobile lordotic lumbar spine at the thoracolumbar junction. Biomechanically, this transition zone is susceptible to injury and is the most commonly injured portion of the spine. Motor vehicle accidents are the leading cause of injury followed by falls and sports-related injuries [1]. Males are at four times higher risk than females. Other organ system injury is encountered in up to 50% thoracolumbar trauma patients [2–6]. High-energy injuries, such as those causing thoracic level paraplegia, have a first-year mortality rate of 7% [7].

Primary goals in thoracolumbar trauma patients are prompt recognition and treatment of associated injuries and expeditious stabilization of the spine and protection of the neural elements.

History and Physical

A good history and physical examination are mandatory in the care of spine trauma patients. Missed spinal injuries are associated with significant morbidity and mortality. The incidence of secondary neurologic deficit is only 1.5% in those injuries identified early. In injuries with delayed diagnosis, this rate increases to 10%. A good history provides important insights into the pathomechanics of the injury. Determining which force vectors predominates helps identify unstable spinal columns and thus dictates the most efficient construct to provide stability.

Complete and serial neurologic evaluation is critical in every patient. Neurologic status greatly impacts treatment options and prognosis. The American Spinal Injury Association (ASIA) Scoring System can assist in documenting, monitoring, and treating neurologic injuries [8]. Patterns of neurologic injuries in this region are highly variable since an injury can occur to the cord, the conus, or the cauda equina. Injury at the cauda equina level carries a better prognosis than a cord injury.

Spine injuries are commonly missed in patients with decreased mentation, loss of consciousness, alcohol intoxication, head trauma, and polytrauma. Once one spine injury is diagnosed, it is especially important to examine the rest of the spine since non-contiguous injuries can be present 15% of the time [9]. It is also important to look for associated injuries outside the spinal column through a thorough trauma evaluation. Fifteen percent of patients may have major visceral involvement. Intrathoracic trauma such as hemopneumothorax, diaphragmatic rupture, and a major vessel injury occur in approximately one-third of the patients who have a neurologic deficit [10]. Pediatric lumbar chance fractures are associated with a 65% incidence of bowel rupture.

Radiologic Evaluation

Initial radiographic assessment includes anteroposterior (AP) and lateral spine films. The AP film should be examined for loss of vertical body height, fracture of the oval-shaped pedicles, increased interpedicular distance, transverse process or rib fractures, malalignment of vertebral bodies, or spinous processes without a history of scoliosis (Fig. 1). Examine the lateral radiograph for loss of body height, disruption of superior or inferior end plate, posterior cortical wall fracture with retropulsed bone, fracture of spinous processes, widening of interspinous distance, and subluxation or angulation of vertebral bodies (Fig. 2). Malalignment in any plane without a history of scoliosis especially in the AP plane suggests the possibility of a fracture dislocation [11]. Plain radiographs are not accurate in determining involvement of the posterior wall of the vertebral body [12]. Computerized tomography (CT) better delineates the bony structures once an injury is identified. A CT scan reveals the integrity of the middle column, the degree of canal compromise, as well as subluxations or fractures of

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facets and lamina (Fig. 3). The presence of two bodies on the same axial cut of a CT scan may indicate a fracture dislocation (Fig. 4), but first assure that the gantry has been angled in parallel to the vertebral endplates. Sagittal reconstructions are helpful in visualizing flexion–distraction injuries and fracture dislocations. Magnetic resonance imaging (MRI) is useful in evaluating those patients with neurologic injury that cannot be accounted for by osseous disruption on plain radiographs and a CT scan. MRI can reveal the injury to the spinal cord, ligaments, annulus fibrosis, disc herniations, and epidural hematomas [14–18].

Classification

One of the earliest classifications of spinal fractures was by Watson Jones in 1931, which was based primarily on diagnosis and treatment of flexion injuries [19]. Since then many attempts have been made to devise a classification system that is easily applied, is reproducible, and guides prognosis and treatment. One of the most popular and useful classification systems is based on the "three-column" theory proposed by Denis in 1983 as an extension of the biomechanical work of Nagel [20,21]. The spine is divided into anterior, middle, and posterior columns (Fig. 5). The anterior column reflects the anterior part of the vertebral body along with the anterior annulus fibrosis and the anterior longitudinal ligament. The posterior wall of the body along with the posterior annulus fibrosis and the posterior longitudinal ligament comprises the middle column. The posterior column includes the posterior arch along with posterior ligaments and facet joint capsules. Fractures can be divided into four types based on this theory (Fig. 6). Injury to the anterior column results in a compression fracture. Injury to both the anterior and middle column with possible retropulsion of bone into the spinal canal results in a burst fracture. Injury to all three columns results in either a flexion–distraction injury or a fracture–dislocation. Some authors point out that the degree of injury to the anterior column in a flexion–distraction injury is minimal and therefore radiographs should be scrutinized for significant translation which helps to differentiate fracture–dislocations from flexion–distractions.

The usefulness of the Denis classification and others, such as those proposed by Allen and Ferguson and Magerl, is diminished by the fact that none relates specifically to optimal treatment or approach [22,23]. These classifications all vary in their complexity and ability to help differentiate between the specific treatment options. A load-sharing classification was described in 1994 to address these issues. It is a classification based on the analysis of failures of short-segment transpedicular instrumentation for fixation of burst

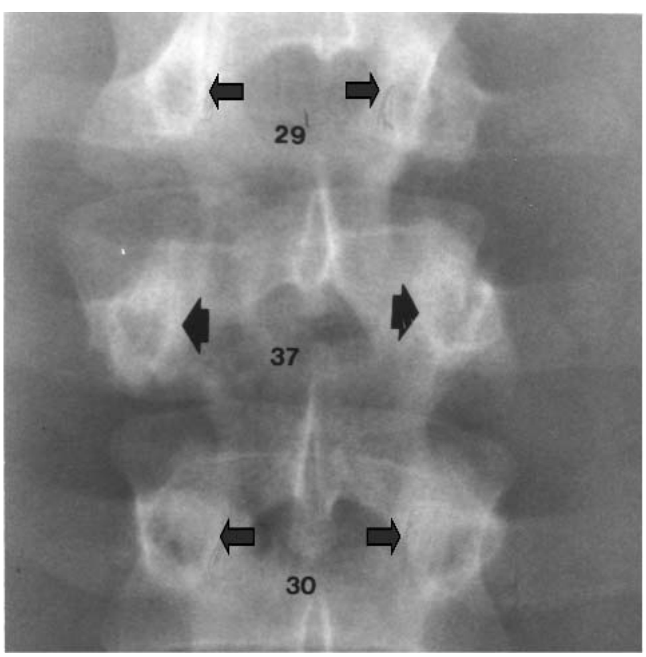

Fig. 1. AP spine X-ray demonstrating widening of the interpedicular distance at the fractured level. The arrows point to the pedicles and the numbers represent the interpedicular distance.

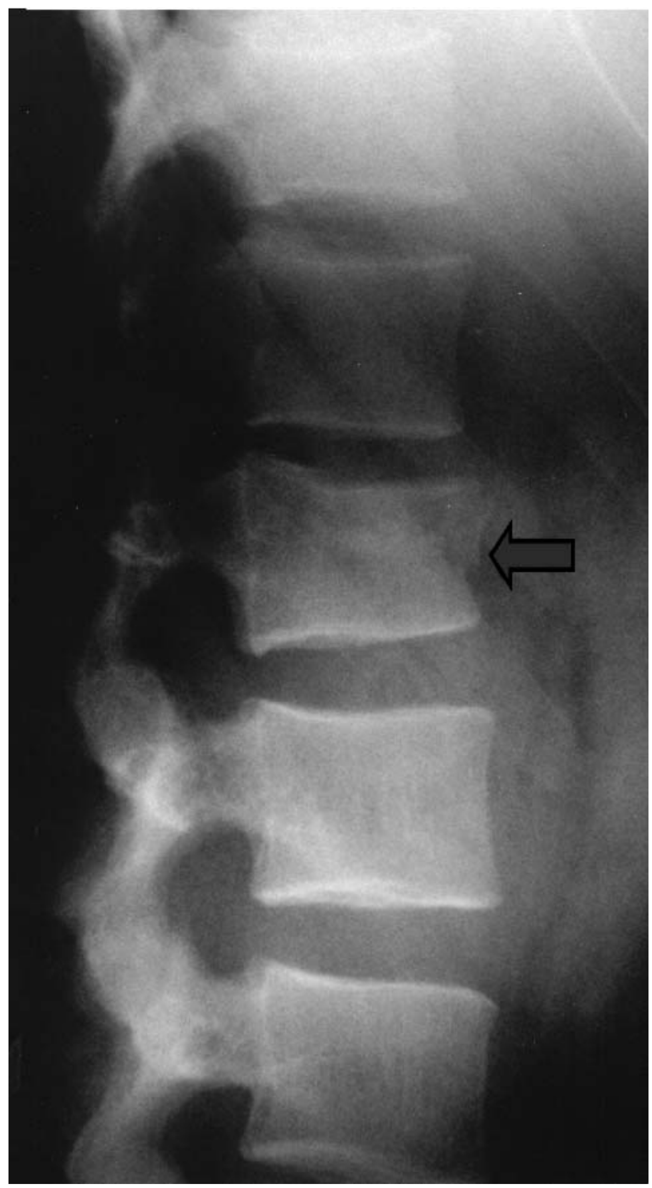

Fig. 2. Lateral spine X-ray demonstrating a compression fracture.

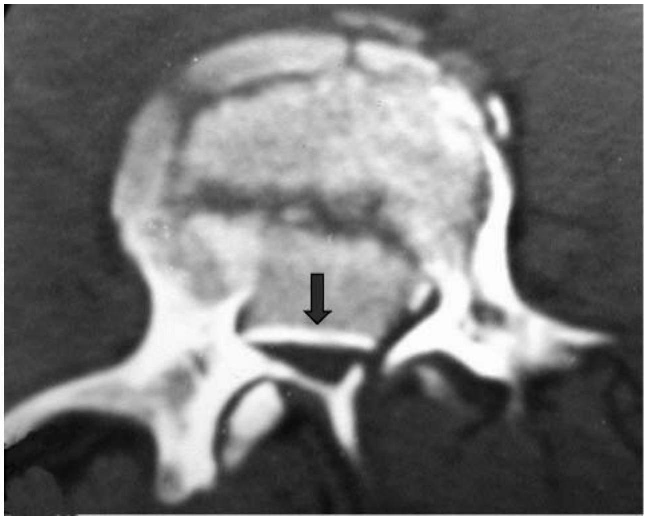

Fig. 3. CT scan demonstrating retropulsion of the posterior wall of the vertebral body into the spinal canal.

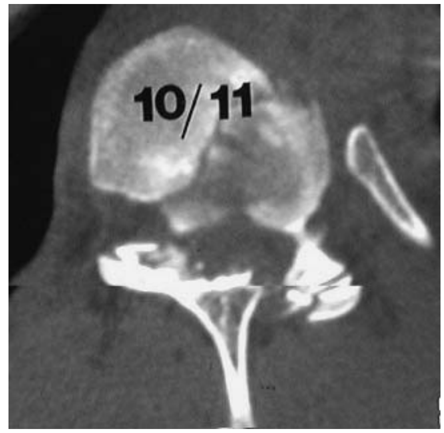

Fig. 4. CT scan demonstrating a fracture dislocation. Note the presence of two vertebral bodies on the same axial cut.

fractures [24]. One to three points are assigned for comminution, fracture displacement, and deformity. Posterior fixation only for low points, anterior fixation only for high points, and anterior and posterior fixation were recommended for high points with translation.

Treatment

Goals of any form of treatment are to obtain a painless, balanced, stable spine with optimum neurologic function and maximum spine mobility. Significant controversy exists about the best method to achieve these goals.

Non-Operative Treatment

Non-operative treatment options include postural reduction, bedrest, ambulatory bracing, and observation. When considering today's cost-conscious hospital environment along with the medical complications of prolonged bedrest, an early goal of non-operative treatment is a mobile patient with or without a brace. The choice of a brace hinges on producing a force vector opposite of the injury force. For example, an extension brace would provide the most stability for a flexion injury. Non-operative treatment is indicated for stable injuries without the potential for progressive deformity or neurologic injury. Gertzbein demonstrated in a large study that kyphotic deformity greater than 30 degrees correlated with increased back pain [25]. This result has not been reduplicated in other studies [26–29,33]. The most devastating complication of non-operative treatment is the development of neurologic deterioration. Denis noted that 6 of 29 non-operatively treated burst fractures developed a neurologic deficit [30]. In Mumford's prospective study of 41 patients with a burst fracture treated non-operatively, one patient developed a neurologic deficit [31]. On the other hand, Reid and Cantor noted no neurologic worsening in their non-operatively treated patients with burst fractures [26,32]. It appears that the rate of neurologic worsening lies between 0 and 20%.

One-column injuries such as compression fractures and posterior element fractures are stable by definition and can be treated non-operatively unless excessive kyphosis is noted, which raises concern for increased pain and deformity in the future. Treatment of two-column injuries, such as burst fractures, depends to a significant extent on the neurologic status. In neurologically intact patients, non-

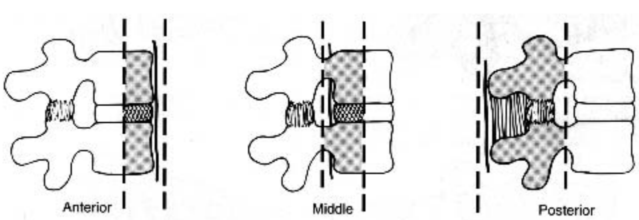

Fig. 5. The spine can be considered as a three-column structure. (Modified from: Garfin S, Blair B, Eismont F, Abitbol J. Thoracic and upper lumbar spine injuries. In: Browner B, Jupiter JB, Levine A, Trafton P, editors. Skeletal trauma. 2nd ed. Philadelphia: W.B. Saunders Company; 1998. p 967–981.)

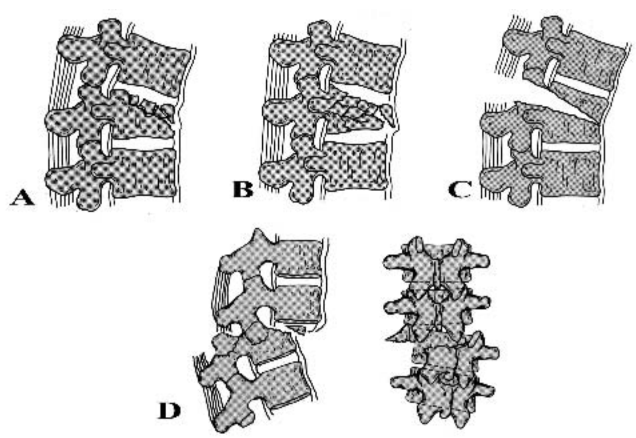

Fig. 6. Denis classification of thoracolumbar trauma. (**A**) Compression fracture. (**B**) Burst fracture. (**C**) Flexion–distraction injury. (**D**) Lateral and posterior view of a fracture dislocation. (Modified from: Garfin S, Blair B, Eismont F, Abitbol J. Thoracic and upper lumbar spine injuries. In: Browner B, Jupiter JB, Levine A, Trafton P, editors. Skeletal trauma. 2nd ed. Philadelphia: W.B. Saunders Company; 1998. p 967–981.)

operative treatment is generally recommended [33]. A short period of bedrest followed by mobilization in a TLSO brace and continued close monitoring for increased kyphosis and neurologic changes are recommended. Operative treatment has been recommended for patients with compression fractures and burst fractures that have greater than 50% loss of vertebral body height or greater than 30 degrees of kyphosis although this is controversial. Difficulty with bracing due to habitus, abdominal surgery, or multiple trauma may preclude bracing and favor operative intervention. The retropulsed bone has been demonstrated to resorb over time on CT scans; however, residual bone may be one factor contributing to spinal canal stenosis in the future [32,34–37]. Flexion–distraction injuries that are completely through bone hinging on the anterior column can be treated with a hyperextension brace counteracting the flexion injury force as long as the deformity reduces, providing good bony apposition of the fracture.

Operative Treatment

Indications for surgical treatment are controversial. Surgery is typically employed in patients with unstable, three-column injuries and significant neurologic deficits. Examples of injuries requiring operative intervention include fracture–dislocations, flexion–distraction injuries, and burst fractures with neurologic deficit. Neurologically intact patients with compression fractures and burst fractures that have greater than 50% loss of vertebral body height or greater than 30 degrees of kyphosis are also considered candidates for surgery, although this is not universally accepted. Progressing from proximal to distal along the spinal column, the ratio of canal size to spinal cord increases and the spinal cord transforms into the more resilient cauda equina. Thus the degree of canal compromise correlates with neurologic deficit when the level of injury is taken into account [38,39]. However, it should be kept in mind that the translation and deformity seen on supine radiographs may be significantly less than that at the time of injury [40]. If a vertical laminar fracture occurs, the dura and nerve roots can be retropulsed and trapped into the fracture site [41]. This may influence the decision regarding anterior versus posterior approach.

Incomplete spinal cord injuries and cauda equina injuries have better neurologic recovery than complete spinal cord injuries. This recovery may be enhanced by decompression of the compressed neural elements. Decompression can be performed directly via an anterior or a posterolateral approach. Indirect, posterior decompression can be performed by using ligamentotaxis through the posterior annulus [16,17]. The results of this method are best if performed within 4 days, and if a posterior approach is chosen after 4 days, direct decompression should be performed via the transpedicular approach [42–48]. A laminectomy alone is indicated for the uncommon circumstance of major compression from a laminar fracture. Otherwise laminectomy alone is not recommended for the decompression of spinal column injuries in that it can further destabilize the spine [49].

Early reports of decompression and stabilization in patients with a neurologic deficit and a thoracolumbar fracture demonstrated improvement that was equal to that of non-operative results in the literature [38,39,50–55]. With advent of newer instrumentation techniques and aggressive direct anterior decompression, the degree of neurologic recovery appears more favorable than earlier reports [28,56–62]. The stabilization can be performed from either anterior or posterior approach using instrumented fusion. Posterior fixation after an anterior approach adds the morbidity of both approaches but may be necessary if adequate anterior fixation cannot be achieved. If such stabilization is not performed, late kyphosis can be expected in patients undergoing a corpectomy [63]. Initial enthusiasm for a short pedicle screw construct has met with late kyphosis [64–66]. Better results may be achieved with the load sharing classification that accounts for fracture anatomy [67]. This classification takes into account the degree of comminution, fracture apposition, and deformity correction. Short posterior constructs are best for flexion–distraction with intact anterior column, mild burst fractures, or fracture dislocations with a point score of 6 or less [65]. Supplemental laminar hooks can significantly increase the pedicle screw construct stiffness without the morbidity of fusing additional levels [68]. The remainder of the higher energy injuries should be treated with a combined anterior and posterior approach.

Bohlman and associates have reported the onset of late pain, deformity, and neurologic worsening [69,70]. In a group of 45 such patients treated with anterior decompression and fusion, 41 had satisfactory relief of pain. Of the 25 patients with a neurologic deficit, 21 experienced an improvement although many years had elapsed since the injury [70]. This reaffirms that direct surgical decompression of the neural elements provides good results even in the setting of late pain and paralysis.

Non-operative treatment is generally recommended for low-energy osteoporotic compression and burst fractures. Vertebroplasty and kyphoplasty are two techniques that show good potential in terms of decreasing pain and improving function in this subset of patients. Early reports demonstrate these techniques to be highly effective with good pain relief and relatively few complications [71–75]. However, long-term results are not yet available, and the indications for these techniques are still evolving.

Summary

Injury to the thoracolumbar junction is a common injury with significant concomitant injury to the other organ systems. Prompt recognition and treatment of all injuries play an important role in improving the outcome. Late pain has been reported in as many as 70–90% of the patients, and it may come from spinal stenosis, segmental instability, foraminal stenosis, or discogenic pain [76,77]. There is some evidence that operatively managed patients have decreased pain but may be subject to other late problems, such as adjacent segment degeneration [25,78].

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