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High Resolution CT of Thoracolumbar Fractures

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Twenty-one patients with thoracolumbar spinal fractures were studied with computed tomography (CT). A vertebral body was involved in 20; 12 had additional fractures of the posterior elements. Five had multiple level injuries. Neurologic deficits occurred in nine and were more common in combined vertebral body and posterior element injury. Five patients had surgical exploration of the spinal canal. CT provided more information than plain films, which missed a vertebral body fracture in one of 20, spinal canal compromise in four of 17, and posterior element fracture in one of 12. CT showed the posterior element injuries in greater detail. CT with intrathecal contrast material showed dural tear in one case. Dural tears were found at surgery in two additional patients studied without intrathecal contrast. All three had lamina fractures and cauda equina symptoms. Prompt repair of associated nerve root herniation led to rapid recovery in two of these patients.

The thoracolumbar junction is a common site of fracture after trauma. About 40% of such fractures are associated with neurologic deficits, a frequency second only to that of fractures in the lower cervical region [1, 2]. Initial recognition of fracture severity and resulting spinal stability is often less than optimal because conventional radiographic studies underestimate damage to bone and soft tissue [3]. Radiographic categorization of fracture type is often offered but is useful only if it affects the subsequent therapy and clinical course. Even so, there is little consensus about the proper treatment for injuries in this region of the spine [3–12].

More accurate initial radiographic evaluation of thoracolumbar spine fractures might affect therapeutic decisions, and computed tomography (CT) has been recommended for this purpose [13–17]. Recent improvements in beam collimation have allowed better spatial resolution which allows not only optimal evaluation of the vertebral bodies and posterior elements in the axial plane but reformatted images in other planes. Further, low dose, water-soluble intrathecal contrast material can quantify the degree of neural compression, and may detect the presence of a dural rent. In our experience, these capabilities of CT make it the imaging method of choice for thorough evaluation of trauma to the thoracolumbar junction, and may greatly assist treatment selection in some cases.

Subjects and Methods

Seventy-one patients admitted to our institution during a 20 month period with acute fractures of the spine had CT scan evaluation, the last 51 patients with high resolution scanning. A total of 21 patients had fractures distributed between T11 and L5, and are the basis of this report. Five of these patients were included in a previous review [13].

All scans were performed on a GE 8800 CT scanner. Slice thickness was 5 mm and slice spacing was 3 mm, with 2 mm of overlap on contiguous slices. Such technique provides sufficiently detailed resolution for image reformation. The study was tailored to the region of abnormality suggested by plain films, clinical signs, or both. For multilevel fractures, CT was limited to those levels where posterior element injury or neurologic compromise was suspected, since our technique limits the study to a 12 cm contiguous

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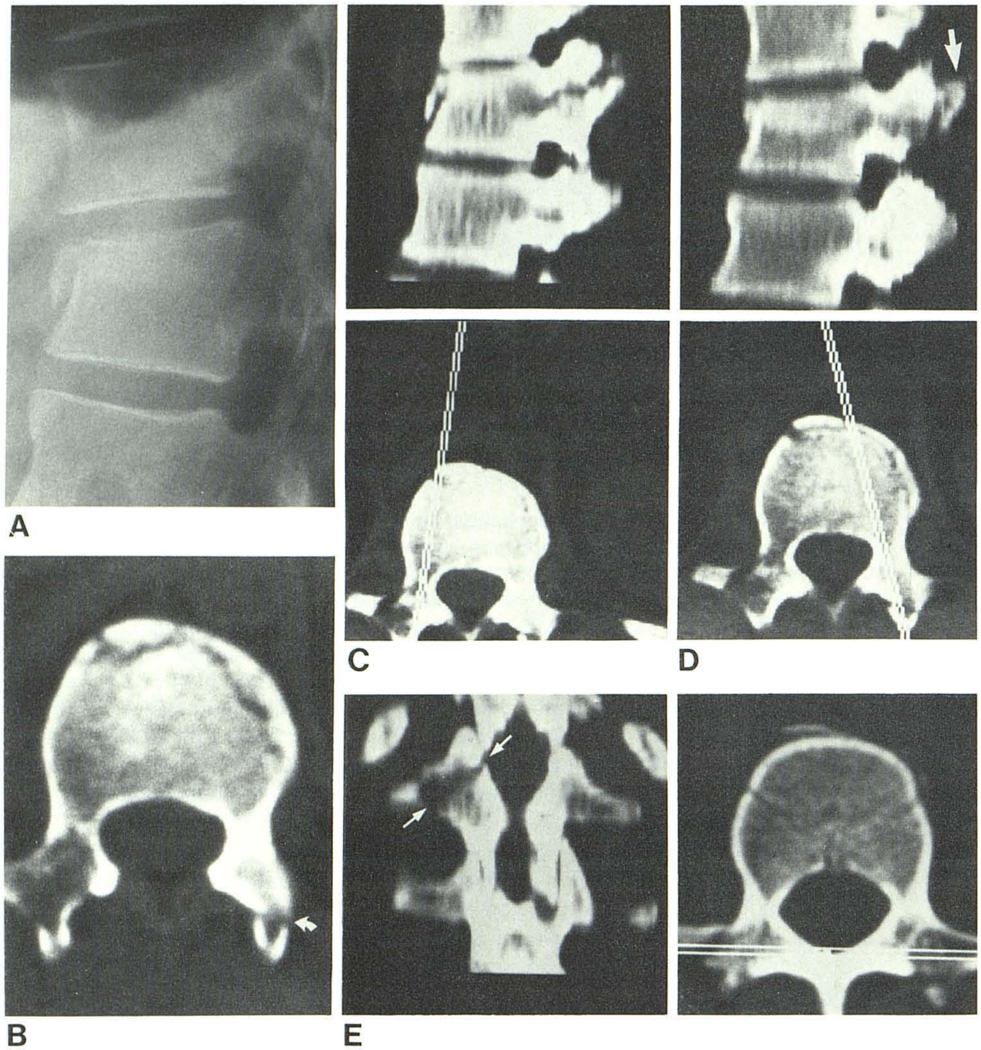


Fig. 1.—Vertebral body and bilateral facet fractures. **A**, L1 body compression. **B**, Axial CT section. Disruption of left superior facet (*arrow*) and questionable abnormality of right facet in addition to anterior compression. **C**, Parasagittal reformation through right lateral mass. Fracture extends into pedicle. **D**, Parasagittal reformation through left facet. Fractures superior tip (*arrow*) displaces posteriorly. **E**, Coronal image reformation verifies oblique fracture through right superior facet (*arrows*). Asymmetry of superior facet tips (left is blunted).

region. Image reformations were performed using a prototype software package provided by the GE Corporation.

The initial plain films were reviewed by one of us (H. M.). Radiographic findings were specifically analyzed for presence of vertebral body fractures, evidence of posterior element involvement, and the degree of canal compromise judged on the following scale: none or mild (about 0–20% compromise), moderate (20%–50%), severe (>50%). Chart review, including operative notes, was performed in each case.

Results

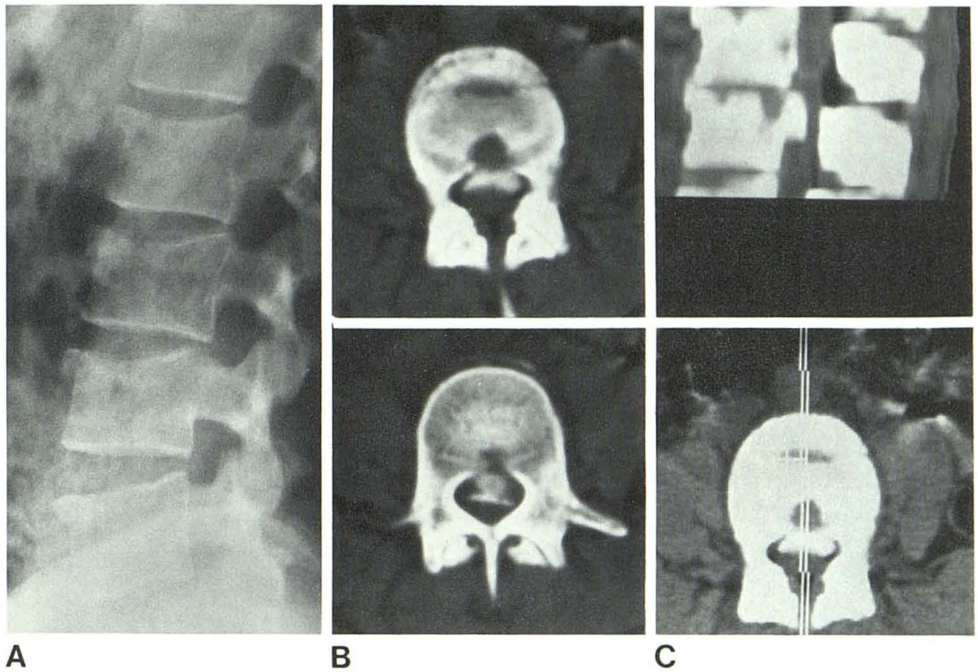
The 21 patients were aged 18–73 years (although most patients were in their third decade) with a mean age of 27. Sixteen patients suffered their fracture after a vertical fall, four were involved in a motor accident, and one suffered direct blunt trauma. Five patients had fractures at multiple levels.

Fourteen of the vertical fall and three of the vehicular victims sustained "burst" fractures characterized on CT by comminution of the vertebral body with varying degrees of fragment retropulsion into the spinal canal (one patient had this injury at three contiguous levels). Resulting spinal canal compromise was moderate or severe in 14 of these 17 patients. Of these 17 patients, 11 had posterior element fractures seen with CT; obvious facet subluxation was seen in one.

Of the remaining four patients, two had only multilevel anterior compression fractures after a vertical fall. In a third, CT showed only transverse process fractures after plain films showed only severe degenerative spurring and failed to reveal an obvious cause for his conus medullaris lesion. The last patient suffered an anterior vertebral body compression and bilateral superior facet fractures (extending into the pedicle on one side) after blunt trauma (fig. 1).

Initial plain films identified the level of fracture and the presence of canal compromise, and suggested posterior involvement in most cases. However, plain film interpretation missed moderate or severe canal compromise by retropulsed fragments in four cases (fig. 2). In addition, a vertebral body fracture was missed in one case on plain films. Posterior element involvement was correctly suggested by plain films by interpediculate distance widening or direct

Fig. 2.—Vertebral body fracture with spinal canal compromise. **A**, Several anterior compression fractures. **B**, CT scan to investigate L5 radiculopathy. Unsuspected canal compromise at L4 level due to retropulsed bony fragment. **C**, Image reformation in midline further defines degree of canal compromise.



visualization in all but one such injury when compared with CT. In another case, laminar fracture was suspected on plain films but disproven with CT. Overall, CT depicted posterior element fractures more directly, and multiplanar image reformation evaluated their extent more thoroughly while graphically displaying facet relationships. CT did not miss any bony lesions shown by other methods at the levels studied.

Nine (43%) of our patients suffered neurologic deficit as a result of the trauma. Eight of these nine patients had posterior element fractures associated with "burst" vertebral body fractures and moderate or severe spinal canal compromise due to fragments. The level of injury in these patients was L1 (four patients), L2 (one), L3 (one), L4 (one), and L1–L3 (one patient, with posterior element fractures only at L1 and L2). Seven patients suffered cauda equina compromise manifest as various nerve root deficits. One had a complete loss of neurologic function at the level of the conus medullaris (fig. 3). The ninth patient with symptoms was a 73-year-old man who was hit by a car who developed decreased sensation and strength in his lower extremities. He only had L1–L3 transverse process fractures. His mechanism of injury was thought to be due to contusion of the conus medullaris as his symptoms improved rapidly.

Of the 12 nonsymptomatic patients, nine had burst fractures, six of whom also showed severe spinal canal compromise. Only three of these nine had an associated posterior element fracture as well. The level of injury in the nine nonsymptomatic patients with burst fractures was T12 (one patient), L1 (one), L2 (four), L3 (one), and L4 (two).

Four of the symptomatic patients underwent surgery shortly after admission. In two with rapidly progressing cauda equina symptoms, a dural laceration with cauda equina herniation was found. Both these patients had operation within 24 hr and showed marked improvement in the week after operation (figs. 4 and 5). A third symptomatic patient with a T12–L1 subluxation and L1 "burst" fracture underwent surgery the day of admission after metrizamide CT which showed evidence of dural laceration (fig. 6). The tear was found at surgery, but no evidence of nerve root herniation was seen; his symptoms did not change during hospitalization. The fourth patient, thought to have a stable fracture, had minimal L5–S1 symptoms on admission; however, these progressed on the third day of hospitalization after conventional tomography, during which the patient was turned into a lateral position. Myelography was then performed; it showed severe compression of the cauda equina (the admission CT scan showed only moderate spinal canal compromise). Surgical fusion was performed, without decompression.

A nonsymptomatic patient underwent surgery after a marked canal compromise at the L2 level was seen. Because surgical stabilization was contemplated, the surgeon elected to decompress the spinal canal at the same time. There was severe compromise of the thecal sac, but no dural tear was seen.

Discussion

The thoracolumbar region is one of the two most vulnerable in the spine for traumatic fracture. This may be due to its greater hypermobility and its more mechanically pivotal location, when compared with the major part of the thoracic spine. In the dorsal region, the sturdy apophyseal joints overlap, limiting extension, and the costotransverse and costovertebral articulations stabilize this region further. At the T12–L1 level, however, the orientation of the facet joints

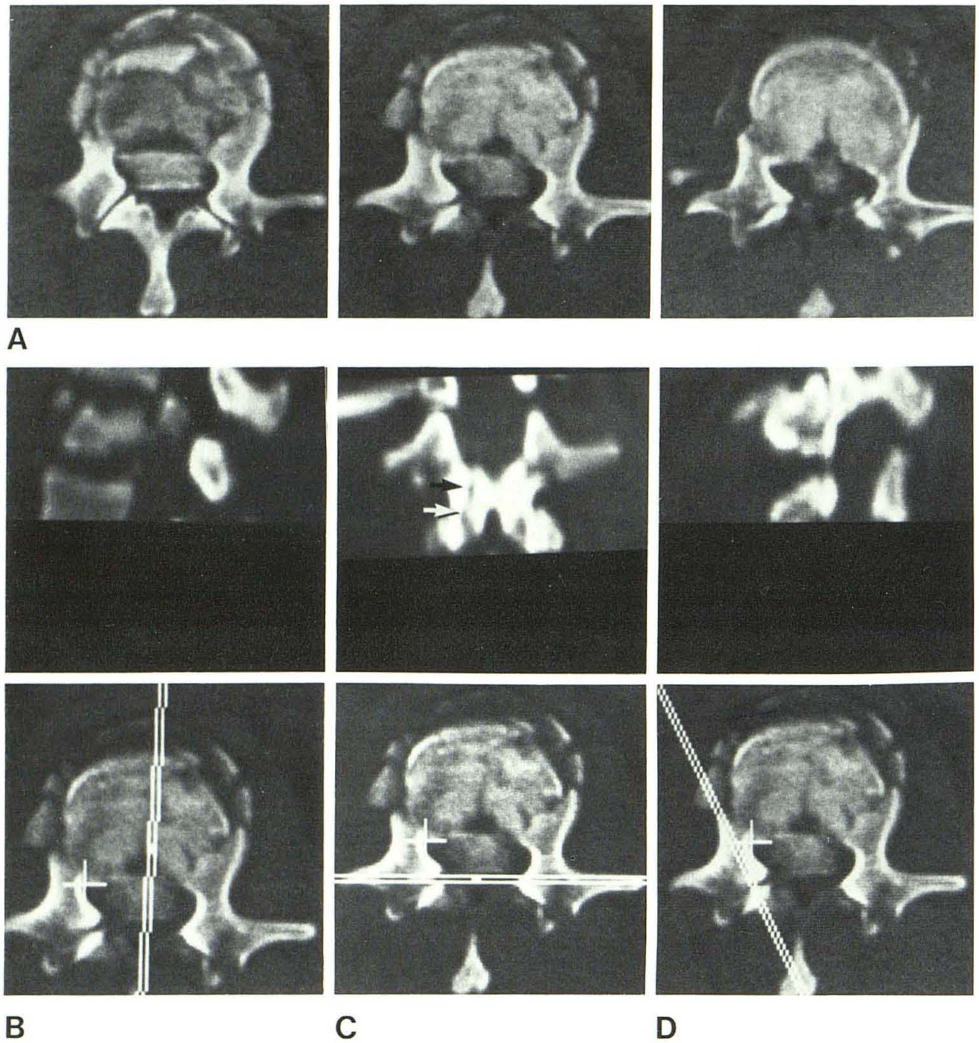


Fig. 3.—"Burst" fracture of L1 vertebral body with complete conus deficit. **A**, Spinal canal fragment, and bilateral facet and right laminal fractures. **B**, Sagittal image reformation better defines midline retropulsed bony fragment. **C**, Coronal reformation through laminae better delineates right-sided sagittal fracture of posterior arch (*arrows*), and also defines left lateral mass fracture. **D**, Right posterior oblique paraaxial reformation defines similar fracture through right lateral mass.

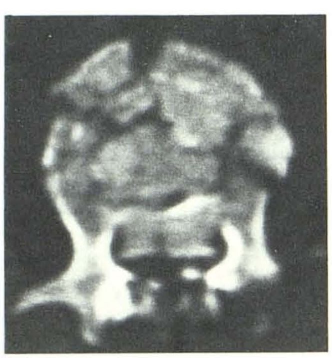


Fig. 4.—"Burst" fracture at L1 level with lower extremity weakness and loss of sphincter tone. Herniated cauda equina roots through rent in dura were trapped in laminal fracture fragments. Rapid improvement after surgery.

changes from an essentially coronal plane to one closer to the sagittal plane. This allows more flexion and extension with appropriate vectors of force. In addition, the combination of a severe axial load and a rigid or slightly extended spine produces a sliding action, which can more easily wedge the posterior elements and may also produce a vertical rent in the dura [10]. Hence the injuries produced by fractures in this region may be more complex than initially suspected on the basis of plain film evaluation.

More accurate evaluation of fractures in the thoracolumbar junction may help resolve the long-standing controversy regarding therapy which involves two separate management problems: structural stability of the spine and treatment of neurologic deficits. The first relates to immobilization of unstable fractures, which have attendant potential for progressive malalignment, pain, or even neurologic complication. Postural reduction, bed rest, and external bracing is advocated by some [4, 7, 8]. Other surgeons favor early laminectomy with internal fixation and fusion [3, 5, 6, 9–12]. The latter opinion claims earlier stabilization permitting more rapid patient mobilization and rehabilitation, while lessening the chances for deformity or development of neurologic dysfunction due to accidental motion of the patient while at bed rest.

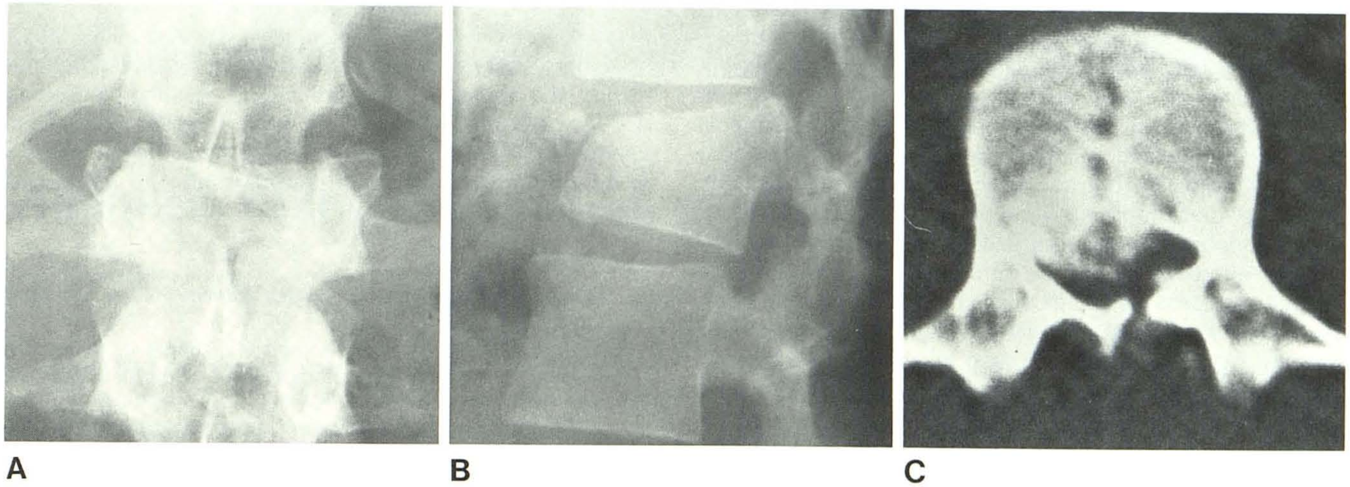


Fig. 5.—Vertebral body fracture with leg weakness due to nerve root herniation. **A**, and **B**, L1 compression with widening of pedicles and element of spinal canal compromise. **C**, Axial CT section. Sagittal cleavage through vertebral body and left lamina. Retropulsed fragment compromises spinal canal. Dramatic improvement followed surgical repair of nerve root herniation.

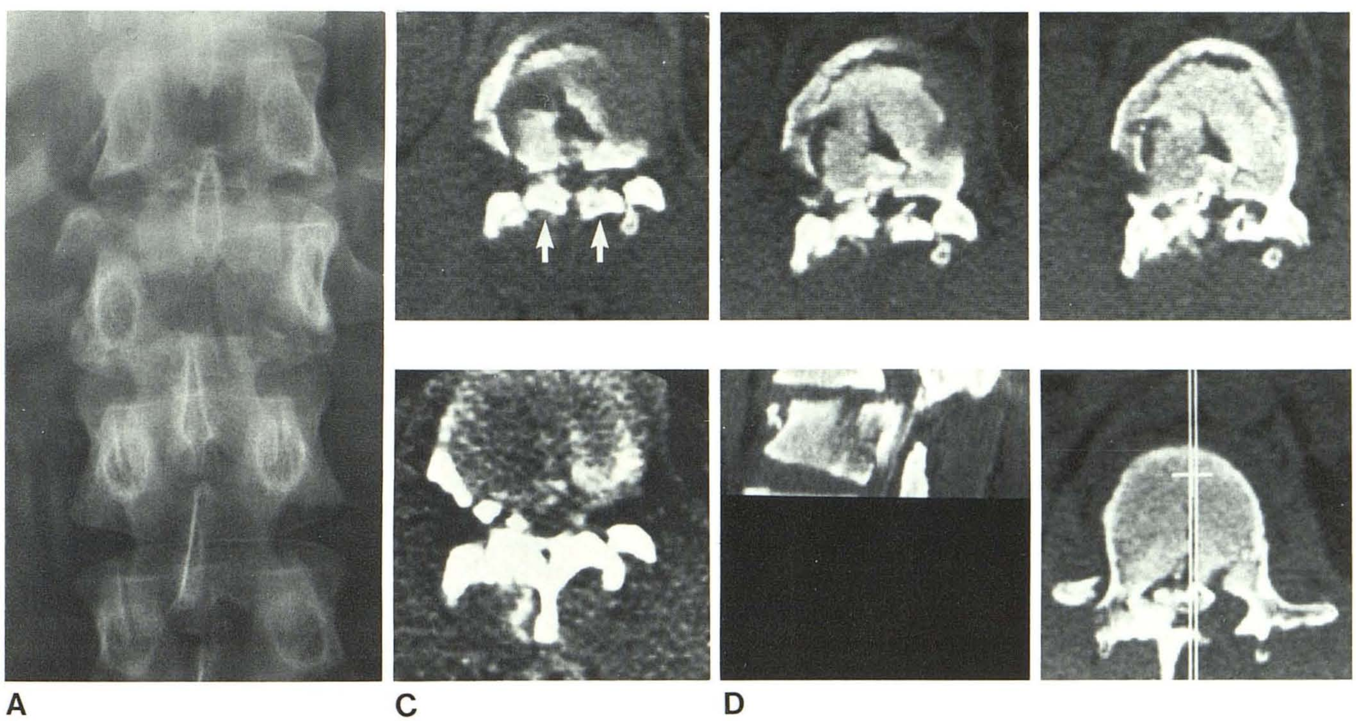


Fig. 6.—Vertebral body fracture with dural laceration. **A**, Compression and pedicle widening of L1. **B**, Axial CT. Anterior subluxation of T12 inferior facets (*arrows*) in respect to L1 superior facets. Metrizamide injected at L4–L5 before scan, leaks into posterior paraspinal musculature. **C**, Section with narrower window. Metrizamide leak seen better. **D**, Lower sections. Left lamina disruption. Sagittal reformation shows compression of metrizamide-filled thecal sac. Dural laceration found at surgery, but no cauda equina herniation through laceration was seen.

Computed tomography can influence planning for stabilization of the spine. Rapid, thorough evaluation with high resolution scanners and image reformation allows early recognition of posterior element disruption and resulting instability. Soft-tissue injury alone, in the form of posterior ligamentous disruption (ligamentum flavum, capsular ligaments, interspinous and supraspinous ligaments), is a source of spinal instability. It is best documented with plain film flexion extension views. However, a vertebral body fracture combined with posterior element fracture strongly indicates instability and is accurately diagnosed with CT. This not only warns those treating the patient against unnecessary movement, but may help select those patients who might benefit by early fusion.

The treatment of patients with neurologic deficits is even more controversial. Complete transection of the sacral spinal cord or cauda equina nerve roots is a permanent injury. However, nerve root compression and entrapment via herniation through a dural rent is amenable to surgical therapy if recognized. Such therapy may prevent permanent neurologic deficits, but the clinical differentiation of such nerve root damage from simple nerve contusion is difficult. Since peripheral nerve root lesions can improve spontaneously with time, the choice for surgical therapy becomes difficult, and proof of its efficacy is almost impossible. Demonstration of a dural rent may help in the decision for surgical exploration, but, as seen in one of our cases, a dural rent need not always be associated with cauda equina herniation even in symptomatic patients.

In our cases, vertebral body fragmentation together with posterior element fracture was seen more often in neurologically symptomatic patients than nonsymptomatic ones. Detection of severe vertebral body fragmentation and marked canal compromise is symptomatic patients may argue for earlier decompression of affected nerve roots. Of course, the CT scan cannot predict whether symptoms are related to continued impingement, trapping, contusion, or even severance at the original point of injury. Nevertheless, if surgical stabilization of a severe fracture is contemplated, a metrizamide myelogram may suggest nerve roots outside the dura and the desirability of exposing the epidural space to look for dural rent and root herniation. Freeing entrapped nerve roots and returning them to their proper anatomic position seems logical [5, 9, 10] (and seemed to have been effective in two of our cases).

We currently use high resolution computed tomography of the thoracolumbar junction region in those patients who show a significant fracture on plain films or those with neurologic deficits. Image reformation through the posterior elements is done when their fracture is suspected on the axial view. Conventional tomography is no longer performed. In patients with incomplete conus medullaris or cauda equina deficits who have either severe bony canal compromise and/or laminar fractures, we have begun using low dose (3–5 ml, 170 mg/dl) metrizamide to assess the degree of thecal sac compression and to delineate a dural rent. Our surgeons believe this approach helps them in the difficult clinical decisions regarding therapy. Since about 40% of fractures in this region are associated with neurologic deficits and since the cost of caring for such patients has risen dramatically, obtaining a thorough initial diagnosis to guide subsequent therapy is ultimately economical.

Our experience indicates that after routine screening radiographs, computed tomography is the method of choice for thoroughly evaluating fractures in the region of the thoracolumbar junction. Plain films alone can underestimate the degree of bony damage and may not disclose spinal canal compromise. Conventional tomography is limited in its three-dimensional reproduction capability and necessitates patient repositioning for more thorough evaluation, thus having the potential of accentuating existing neurologic deficits or producing new ones in an unstable injury. Conventional myelography requires even more patient manipulation, thus potentiating both the discomfort to the patient and the attendant risks.

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