Anterior transthoracic surgical decompression of acute spinal cord injuries

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Three cases of incomplete acute traumatic myelopathies resulting from anterior spinal cord compression were managed by direct surgical decompression by way of the transthoracic approach. The surgical anatomy, technique, diagnostic work-up, and indications for the procedure are discussed.

KEY WORDS • acute spinal trauma • anterior spinal cord compression • direct transthoracic decompression • lateral fusion

The authors have recently encountered three cases of traumatic anterior cord compression resulting in incomplete myelopathies which were treated surgically by the anterior transthoracic approach. The purpose of this paper is to present these cases and describe their surgical management in detail.

Case Reports

Case 1

This 43-year-old man was involved in a light airplane crash on September 2, 1973. He was taken to a nearby hospital where he was noted to be in hemodynamic shock, with a distended abdomen and moderate respiratory distress (a chest film showed fractures of the fourth and fifth ribs on the right). He did not move his legs. He promptly underwent a laparotomy at which time a large retroperitoneal hematoma was encountered and removed. His immediate postoperative course was uneventful.

Examination. A neurosurgical consultation revealed the patient to have a complete paraplegia with a sensory level to pinprick and temperature to approximately T-7. Touch and proprioception were preserved. Thoracic spine films revealed a fracture dislocation at T-6. Subsequently, an attempt at myelography was unsuccessful. Because of suspected mediastinal widening, the patient was transferred to the Maryland Institute for Emergency Medicine, University of Maryland Hospital on September 8, 1973.

On admission, the patient's condition was stable, and a Foley catheter was in place. There was a tender bone prominence in the midthoracic area. Neurological examination revealed a complete paraplegia, with a symmetrical sensory level to both pinprick and temperature to approximately T-7 with preservation of touch and proprioception. A
combined lumbar and cisternal myelogram revealed a complete block (Fig. 1). Over the first 4 days following admission, the patient’s neurological status remained unchanged.

*Operation.* On September 9, the patient underwent anterior thoracic spinal decompression at the T5–7 level through a right lateral thoracotomy. The postoperative course referable to the thoracotomy was uncomplicated. On the first postoperative day, the patient was noted to have some dorsiflexion of the right foot. By the second day, this had improved, and the sensory level on the left had markedly diminished. Subsequently, there was gradual improvement of the motor function on the left, which involved all muscle groups by October 3. Also on this date, movement was first noted in the left foot. A postoperative chest film revealed complete resolution of the spinal block (Fig. 2). He was transferred to a hospital closer to home on October 24, and his condition continued to improve.

On December 3, the patient was readmitted to the University of Maryland Hospital for evaluation of his spinal fusion. X-ray films revealed the fusion to be solid without evidence of motion. At this time, the patient could move all muscle groups of both legs, the right being better than the left. When evaluated 1 year postoperatively, the patient could walk with the help of hand crutches and was still improving. His sensory impairment had completely resolved.

*Case 2*

This 58-year-old farmer was admitted to the Maryland Institute for Emergency Medicine at the University of Maryland Hospital on November 22, 1973, after falling 12 feet from a hayloft and landing on his back.
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and buttocks. He had a short period of unconsciousness, and found when he awakened that he could not move his legs.

Examination. On admission to the hospital he had a severe flaccid paraparesis with only slight foot movement and hip flexion bilaterally, worse on the right. Proprioception, pain, and touch were intact throughout, although there was a hypalgesia from the knees distally including all the sacral dermatomes. His rectal sphincter was weak, and there was areflexia in his legs. Spine x-ray films showed a T-12 compression fracture with posterior displacement of a piece of the body into the neural canal. Tomography confirmed this and myelography showed a partial block at this level with an extradural defect on the right. Selective catheterization of the intercostal and lumbar vessels revealed the origin of the artery of Adamkiewicz to be primarily from the left ninth intercostal vessel (Fig. 3). The anterior spinal artery was displaced posteriorly at the fracture site but otherwise appeared normal (Fig. 4). Both intercostal arteries at T-12 were shown to be occluded.

The patient improved during the first 6 days and then reached a plateau so that on December 5, he had 50% strength in the right leg and 80% in the left. His sensation was unchanged.

Operation. On December 6, a thoracotomy was performed through the eighth interspace with resection of the proximal 12th rib head. After T-12 and L-1 discectomy, the posterior one-third of the body of T-12 was removed with a drill by piecemeal resection. The dural sac was intact and free after this, and a stenting graft was placed in the defect and screwed into the bodies of T-11 and L-1.

Postoperatively, the patient showed progressive improvement so that 6 months later he was able to walk unassisted, had normal sensation, bowel, and bladder function. His only defect is a slight weakness of dorsiflexion of the right foot.

Case 3

This 20-year-old, mentally retarded woman was admitted to the University of Maryland Hospital on March 17, 1974, after having jumped from a second story window at a State Hospital. She landed on her back and was rendered paraplegic immediately.

Examination. On admission, she had no movement in her legs except very weak extension of her feet; this was worse on the left. She was insensitive to all stimuli from S-1 distally bilaterally. There were no reflexes in the legs and her sphincter was atonic. X-ray films showed a compression fracture of the body of L-1, fracture of the transverse process of L-2, and a Colles fracture of the right wrist. Tomography of the L-1 area showed fracture of the L-1 lamina, widening of the pedicles at this level and bone fragments displaced into the anterior part of the neural canal. Myelography showed a complete block at the upper border of L-2. Angiography demonstrated the origin of the artery of Adamkiewicz from the right 12th intercostal artery (Fig. 5 left). The anterior spinal artery was deviated to the left and posteriorly and could not be traced beyond the lower margin of L-1 (Fig. 5 right). Following this procedure, the patient’s motor function deteriorated slightly.

Operation. On March 21, she underwent a left lateral thoracotomy through the eighth
interspace with resection of the proximal portion of the 12th rib head. After exposure of T-12, L-1, and L-2 bodies, a discectomy of the T-12 and L-1 interspace was done and the posterior third of the body of L-1 was removed with a drill by piecemeal resection. One fragment had pierced the dura and arachnoid; this was repaired with suture and muscle stamp. A stinting bone graft was placed in the defect and screwed to T-12 and L-2.

Postoperatively, the patient's course was complicated by overt psychotic behavior, generalized motor seizures, thrombophlebitis of the left leg, and pulmonary emboli. Despite this, the patient improved neurologically so that when last seen 5 months after admission, she had regained function in all motor groups sufficient to walk unassisted. She has regained bladder and bowel function completely and is hypalgesic in her legs.

Surgical Procedure

The injury sustained in Case 1 is a typical spinal cord injury (Fig. 6 left). These injuries may result in compression of the spinal cord over several segments. The myelogram in Case 1, performed from both the lumbar and cisternal routes (Fig. 1), revealed a complete spinal block from the midportion of the body of T-5 to the midportion of the body of T-7. It is apparent that surgical decompression would be necessary over all three segments.

The transthoracic approach to the thoracic spine has been well described elsewhere.6
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Fig. 5. Case 3. Left: Angiogram, anteroposterior projection, with injection of the right 12th intercostal artery (RT 12) shows the artery of Adamkiewicz and the anterior spinal artery, which is deviated to the left. Right: The lateral view shows the artery of Adamkiewicz (AA) and the anterior spinal artery (ASA). The anterior spinal artery is seen to deviate posteriorly over the body of T-12 and cannot be traced beyond its lower margin.

Briefly, a posterior lateral thoracotomy is performed from either the left or right side. The heads of the ribs obscure the pedicles and disc spaces and must be resected in order to gain access to these structures (Fig. 6 left). In Case 1, two ribs were removed. The appropriate foramina are easily found by following the intercostal nerves centrally.

At this point, the spinal surgical procedure begins in a similar fashion as that so well described by Perot and Munro; however, the amount of bone removed is much more extensive, and a lateral thoracic fusion is performed. First, the pedicle at the midpoint of the fracture is removed with a small angled punch, along with parts of, or the entire adjacent pedicles if necessary (Fig. 6 left and center). Following this, the highspeed air drill is used to resect the bone and adjacent disc material immediately ventral to the posterior cortical bone of the vertebral bodies. In this way, a thin shelf of bone immediately adjacent to the posterior longitudinal ligament and dura is left intact. Therefore, resection of bone can proceed without the spinal cord falling ventrally as the resection progresses, and thus obscuring the view and exposing the cord to surgical injury. Sufficient subcortical bone is removed across the midline in order ultimately to allow for decompression of the entire ventral surface of the cord as demonstrated in Fig. 6 center. After the subcortical bone has been removed with the air drill, the thin shelf of bone adjacent to the posterior longitudinal ligament is removed piecemeal with a punch or a small rongeur, and decompression is completed (Fig. 6 right). It should be pointed out that bone bleeding can be readily controlled with bone wax as subsequent fusion is accomplished laterally.

Following decompression, a lateral fusion is accomplished with a template of bone taken from the iliac crest, which is then secured with cancellous screws as illustrated in Fig. 7. The patient can be mobilized after 2 to 3 weeks with a Jewett- or Taylor-type brace. Figure 2 shows the screws of the graft in place.

The bone graft is taken from the midportion of the iliac crest and is a full-thickness graft, including both cortices. It must be long enough to bridge the vertebra both above and below the midpoint of the fracture, as shown
FIG. 6. Left: Drawing illustrates a typical injury such as that sustained in Case 1; the fifth and sixth rib heads have been removed exposing the foramina between T5-7; the nerve roots are not shown at these levels in order to show the ventral spinal cord with clarity; the solid line represents the normal plane of the ventral surface of the spinal cord. Note that the injury has caused displacement of the dorsal bodies of T5-7 and compression of the ventral spinal cord in the area outlined by the broken rectangle. The osteotomy begins with resection of the center pedicle (T-6). Center: The extent of the completed bone resection in the coronal plane is outlined by the broken line; note that the resection is carried across the midline to the opposite pedicle, which can be readily palpated with a dissector. Right: The completed resection in the longitudinal plane. Note that the normal contour of the ventral spinal cord has been re-established; the pedicle of T-6 has been completely removed and that of T-5 and T-7 subtotally resected; the facets remain intact.

FIG. 7. Drawings illustrating the completed decompression and lateral fusion in Case 1. Left: The template of bone is shown in both the coronal and longitudinal planes; the screws, as shown, should pass from cortex to cortex of the vertebral body. Right: the relationship of the graft to the decompression is shown; note that the graft in no way compromises the decompression. in Fig. 7. The graft is notched so that a portion of it may be countersunk between these vertebrae and give added support. This may necessitate removing a small amount of the crushed vertebra and disc material. The bone graft is then secured to the vertebra with buttress-threaded, large-diameter, cancellous screws.* The screw is placed through a predrilled hole (of smaller diameter) and care must be taken to direct the screw in a coronal plane to avoid vital structures. The screw should extend through the opposite cortex of the vertebra for firm fixation. The thoracic vertebrae have an intrinsic stability because of the rib cage, and therefore, with the addition of a bone graft, it has been our experience that these patients can be mobilized quite soon after surgery.

*Cancellous screws made by Zimmer Corporation, Warsaw, Indiana 46580.
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Discussion

The high morbidity associated with the posterior approach to anteriorly placed lesions of the thoracic spine has been well documented.\textsuperscript{2,4,6,7,9} On the other hand, the anterior approach to these lesions has been shown to be safe and effective.\textsuperscript{2,4,6} Recently, Chou and Seljeskog\textsuperscript{2} have described, in general terms, extensive thoracic decompression by way of the transthoracic approach for congenital and acquired thoracic deformities associated with myelopathies, employing "osteotomy . . . by the use of chisels, curettes, and rongeurs." Anterior strut graft fusion is then performed.

Acute injuries of the thoracic spine frequently produce anterior compression of the spinal cord, sometimes over several segments, as a consequence of herniated disc, posterior angulation of the vertebral body, posterior displacement of bone fragments, or a combination of these. Since external reduction of fracture dislocations of the thoracic spine is not possible, the posterior approach to the thoracic cord by laminectomy is frequently used in order to effect decompression. This procedure has serious limitations, particularly if cord compression results from displaced anterior structures, for these cannot be approached by laminectomy without hazardous retraction of the spinal cord. Therefore, the posterior approach is an attempt to accomplish indirect decompression, and the specific cause of the anterior compression cannot be dealt with directly. On the other hand, the anterior approach to the thoracic spine provides excellent direct exposure to these anterior structures which can then be removed in order to effect decompression without manipulation of the cord.\textsuperscript{2,4,6,7}

Surgical Procedure

The transthoracic anterior approach provides easy and wide exposure to the thoracic spine as has been described by others.\textsuperscript{2,4,6,7} In the patients presented in this paper, operations were carried out at levels from T-5 to L-2 with little technical difficulty. We agree with Chou and Seljeskog\textsuperscript{2} that it is easier to "look down" the chest than "look up," and the approach should be planned with that in mind. Exposure as far down as L-2 can be accomplished by thoracotomy at the T-8 or T-9 interspace and by anterior reflection of the posterior leaf of the diaphragm. We would also like to emphasize the importance of removal of the rib heads at the site of injury, and the use of the high-speed air drill.

The spinal surgical procedure described in this paper is relatively simple, and has the following clear advantages: 1) it allows for removal of the offending pathology under direct vision without dangerous manipulation of the spinal cord; 2) the procedure does not require further disruption of the spinal stability by removal of posterior elements; 3) decompression can be accomplished without resorting to extensive bone resection or corpectomy; 4) fusion is accomplished laterally, thus obviating the need for interposing bone between the "osteotomy" and the spinal cord, and allows for the free use of hemostatic agents in the area of bone removal without fear of retarding bone fusion; and 5) the patient can be allowed to walk early with back bracing.

Diagnostic Work-up

In the presence of a complete myelographic block, combined cisternal and lumbar myelography should be considered in order to determine the longitudinal extent of the block. This may be important in planning appropriate surgery. In addition, diagnostic work-up should include tomography if there is any question regarding displacement of posterior bone elements into the spinal canal. It has been pointed out by Chou and Seljeskog\textsuperscript{2} that intercostal arteries can be ligated at multiple levels without producing spinal cord ischemia. It should be recalled that the spinal radicular arteries are given off proximal to the point of ligation of the intercostal arteries at the time of thoracotomy; however, the radicular arteries could be injured during the process of disarticulation of the heads of the ribs, removal of the pedicle, or during the osteotomy. If the artery of Adamkiewicz were injured, cord ischemia could occur. Since the transthoracic approach can be performed from either the left or right side with facility, localization of the origin of this artery may be important in planning the laterality of the approach, as has been previously suggested in the literature.\textsuperscript{1,4-6} Spinal angiography at times may demonstrate both patency and displacement of the anterior spinal artery (Figs. 3, 4, and 5); the longitudinal extent of the dorsal dis-
placement of the anterior spinal artery may indicate the limits of the cephalad-caudad cord compression, and in the event of complete myelographic block, may obviate the need for combined cisternal and lumbar myelography, as in Case 3.

We have performed spinal angiography for these reasons, but primarily recommend it in those cases in which the fracture site is between T-8 and L-1 where the artery of Adamkiewicz most commonly originates. However, if spinal angiography is not available, this does not contraindicate the use of this surgical approach, for its advantages may far outweigh the risks of cord ischemia. One need only to keep in mind the following: 1) experience has shown that cord ischemia is uncommon following anterior thoracic procedures, despite operations involving multiple levels; 2) the artery of Adamkiewicz usually originates between the spinal levels T-8 to L-1, and most often on the left side; 3) the radicular arteries, including the artery of Adamkiewicz, originate proximal to the point of surgical intercostal artery ligation at thoracotomy; and 4) careful dissection around the intervertebral foramina will reduce the risk of injury to these radicular arteries.

**Indications**

We do not recommend the anterior transthoracic approach for all injuries of the thoracic spine. It should not be performed when there is displacement of posterior bone elements into the spinal canal or when a posterior penetrating injury exists, except perhaps as a combined procedure. If there is a question regarding bone elements in the canal, tomography should be performed. It is questionable whether this procedure should be used in complete sensorimotor spinal cord lesions with or without complete spinal block. Under these circumstances, there is some prognostic advantage in viewing the spinal cord at surgery in order to assess the extent of anatomical injury. This is more readily accomplished by the posterior approach. Furthermore, in our experience and that of others, complete traumatic spinal cord injuries carry a bleak prognosis with or without surgical decompression.

The anterior approach should be considered in cases of partial injury of the thoracic spinal cord, particularly when anterior compression can be demonstrated clinically and/or myelographically, and there is no intraspinal displacement of posterior bone elements. It is the procedure of choice in the anterior spinal cord syndrome when either partial or complete myelographic spinal block is present. As demonstrated in Case 1, spinal cord compression over several segments does not rule out the procedure, since an extensive longitudinal decompression can readily be accomplished by the anterior transthoracic approach.

**Addendum**

Since submission of this manuscript for publication, five additional cases of incomplete thoracic cord injuries have been decompressed by way of the transthoracic approach. Results have been excellent in four cases and failure in one case.

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