Retropleural thoracotomy

Technical note

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Herniated thoracic discs, unlike their lumbar counterparts, are difficult to read and safely resect using traditional posterior approaches. Historically, the use of a laminectomy for thoracic disc resection has yielded poor clinical outcomes. Posterolateral and anterolateral approaches have become the standard surgical means of treating these lesions. The traditional anterolateral approach, the transpleural thoracotomy, is an extensive procedure that requires direct retraction of the lung, a deep surgical field, and postoperative closed-chest drainage. An alternative to this anterior approach, the retropleural thoracotomy, is described here. This approach provides the shortest direct route to the thoracic spine and leaves the pleura intact. A smaller incision and less retraction than traditional approaches may reduce postoperative pain and pulmonary-related complications. The retropleural thoracotomy is a valuable technique for the neurosurgeon treating thoracic disc disease.

KEY WORDS • retropleural thoracotomy • intervertebral disc • thoracic spine • discectomy

Thoracic disc disease is not amenable to the posterior surgical approaches and techniques used in the lumbar spine. The thoracic spinal cord occupies a greater proportion of the spinal canal than the lumbar thecal sac. The spinal cord, too, tolerates less retraction than the free-floating nerve roots of the lumbar spine. These factors, often exacerbated by calcification of herniated thoracic discs, limit the ability of the surgeon to work around the thecal sac to extract disc fragments in this region. Posterolateral and anterolateral approaches that provide access to the disc space without requiring excessive retraction of the spinal cord have been developed for the surgical treatment of thoracic discs.

The advantage of posterolateral approaches, such as the costotransversectomy and the lateral extracavitary approach, is that the surgeon is familiar with the anatomy. These approaches are most useful for soft or lateral discs, but they may, in experienced hands, be used for resection of midline or calcified discs as well. The anterolateral approaches provide exposure across the midline and a visible corridor so that the disc may be removed away from the spinal cord. These factors may facilitate the removal

of large central discs, calcified discs, or discs with intradural extension.

There are three general anterolateral approaches to the thoracic spine. The transpleural thoracotomy, first described by Perot and Munro⁵ and Ransohoff, et al.,⁶ is the traditional route, and it affords wide exposure of the ventral thoracic spine from T-3 to T-11. The operative field is deeper than with other techniques, which necessitates significant retraction of visceral structures, including the unprotected lung. The rib head, aorta, or vena cava may partially obscure the spinal canal. Depending on the patient's anatomy, the spinal canal may not be visible until the lesion has been resected. A chest tube must be placed at the end of the procedure to prevent the development of a pneumothorax. Although the standard transthoracic approach allows wide access to the ventral thoracic spine, it is an extensive undertaking associated with potential morbidity that may make it unsuitable for some patients, especially those with marginal pulmonary function.

The retropleural thoracotomy, refined by McCormick,⁴ is described in this paper. By more directly approaching the spine and avoiding pleural entry, this technique addresses some of the shortcomings of the transpleural approach. Because there is no direct retraction of the unprotected lung, the risk of pulmonary complications may be

Abbreviations used in this paper: CSF = cerebrospinal fluid; PLL = posterior longitudinal ligament; VB = vertebral body.

Fig. 1. Artist's drawing. Patient position for retropleural thoracotomy. Incision A is used for upper thoracic lesions, and Incisions B and C for midthoracic and thoracolumbar lesions, respectively. (Used with permission from McCormick.)

reduced. The trajectory to the spine is shorter and more lateral than traditional approaches, which provides early identification of the ventral dura and the foramen. The surgeon can see and therefore protect critical neurovascular structures, which may reduce the risks of anterolateral exposure of the thoracic spine.

The techniques for a final alternative, thoracoscopic surgery, have been evolving at a rapid pace in the last decade. It offers minimally invasive ventral access to the thoracic spine. Proponents of thoracoscopic surgery point to equivalent operative time, reduced postoperative pain, and comparable clinical results compared with those of traditional approaches.⁷ These procedures require highly specialized equipment and training, and they are practiced at a few dedicated centers. With further study the indications for thoracoscopic surgery may increase.

SURGICAL TECHNIQUE

Preoperative Planning

The side of approach is determined by a combination of factors, including the vertebral level and location of the lesion. If the herniated disc is predominantly on one side of the spine, an ipsilateral approach provides the most direct surgical route. Many surgeons are more comfortable approaching the upper thoracic spine from the right, avoiding the heart and great vessels. The aorta is mobilized during a left-sided approach in the middle and lower thoracic spine; it is more tolerant of retraction than the vena cava.² At the thoracolumbar junction, a left-sided approach has the additional advantage of allowing surgeons to avoid the liver. Another consideration in the lower thoracic spine is the artery of Adamkiewicz, which is found between T-9 and L-2 in 85% of specimens and enters from the left in 80%.³ If the use of cautery in the neural foramina is avoided, the medullary arteries are protected and routine preoperative angiography is unnecessary.

It is important to evaluate the vertebral level of the lesion and determine a suitable method for verifying that segment in the operating room. The level of the herniated disc is often determined by the radiologist and surgeon by using the sacrum or odontoid process as a reference point. These fixed landmarks, however, may not be available in the operating room, either on the neuroimages or on fluoroscopy. It is therefore important to know the relation of the involved level to the last VB associated with a rib. The surgeon must have determined the size of the last rib,

because if it is small, it may be confused with a transverse process. Knowing the number of ribs and the number of non-ribbed lumbar vertebrae, as well as the anatomical appearance of the lumbosacral region (with particular attention to the presence of a transitional vertebra), will help to ensure proper intraoperative determination of the pathological level.

An epidural catheter for the perioperative delivery of morphine may be placed prior to patient positioning and induction of anesthesia. The patient is placed on the operating table in a lateral position. A beanbag is placed beneath the patient to avoid pressure points and add stability. The dependent axilla is padded with a soft roll. The lower leg is flexed at the knee and hip for additional stability. A pillow may be placed between the legs. Thoracolumbar lesions should be centered over the table break, if possible, to aid intraoperative exposure. A double-lumen endotracheal tube will aid approaches to the upper thoracic spine (above T-6) by allowing the anesthesiologist to deflate the ipsilateral lung. The anesthetic and instrument tray should be arranged to allow the operating table to be lowered completely.

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Intraoperative fluoroscopy or radiography is used to confirm the proper rib level of the incision. For upper and middle thoracic lesions the incision is made over the rib of the involved level. In the upper thoracic spine (T3–4) a hockey stick-shaped incision is made along the medial and inferior border of the scapula, which is then freed of muscular attachments and rotated superiorly. A standard incision is made for lesions between T-5 and T-10. Beginning 4 cm lateral to the posterior midline, the incision is made along the rib at the involved segment (T-8 rib for a T7–8 intervertebral disc) and extended to the posterior axillary line. At the thoracolumbar junction, the incision is made two levels rostral to the involved segment (T-10 incision for a T-12 lesion)^{1,4} (Fig. 1). A subperiosteal dissection is used to free the intercostal muscles along an 8- to 10-cm length of rib. The exposed portion of the rib is resected and saved for use as an autograft, and the cut ends are waxed (Fig. 2 *upper left*). The proximal rib remains attached to the VB and transverse process.

In the rib bed a distinct tissue layer, the endothoracic fascia, is identified. This layer is continuous with the inner periosteum of the ribs and thoracic vertebral bodies. It is analogous to the transversalis fascia that lines the abdominal cavity. Within this layer lie the intercostal nerves and vessels, thoracic sympathetic chain, thoracic duct, and azygous vein.⁴

The endothoracic fascia is sharply incised in the rib bed, exposing the parietal pleura (Fig. 3). A thin layer of loose areolar tissue may be found in the potential space between the endothoracic fascia and the pleura. The pleura is bluntly dissected free from the endothoracic fascia by using a Kittner clamp. Any small tears in the pleura are repaired primarily with suture. For lesions above T-6 the ipsilateral lung should be deflated. The ribs are then spread with a crank retractor, and a malleable table-mounted retractor is used to retract the lung gently. The opening in the endothoracic fascia is extended proximally to the rib head and the pleural dissection is carried proximally to the ver-

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Fig. 2. Artist's drawings. *Upper Left:* The exposed portion of the rib is resected. *Upper Right:* The endothoracic fascia in the resected rib bed is incised. *Lower Left:* The blunt dissection of the pleura is extended to the VB. Dissecting the pleura rostral and caudal to the involved segment helps to prevent tears. *Lower Center:* With a retractor (a) on the lung, the neurovascular bundle (b) is freed and partially mobilized from the underlying fascia. The fascia is incised and elevated from the vertebrae in the subperiosteal plane. The dissection is carried out over the rib head, disc space, and vertebral bodies. Finally, the rib head (c) is removed to expose the pedicle and disc space. *Lower Right:* The sympathetic chain is divided, and the disc is removed. (Used with permission from Birch, et al.)

tebral column (Fig. 2 lower left). The ligaments attaching the rib to the vertebra, the costotransverse and radiate ligaments, are divided. Any remaining soft tissue is detached and the rib head is disarticulated and removed (Fig. 2 lower center).

The endothoracic fascia is incised over the involved disc space. This divides the sympathetic chain, which rarely has any clinically significant result in the thoracic spine. The fascia and vertebral periosteum are reflected rostrally and caudally away from the disc space. Contained in the fascia are the intercostal vessels that overlie each vertebra at the midbody. For a single-level discectomy these vessels can be preserved. Curettes and nerve hooks are used to define the pedicle margins.

The disc is incised and removed with rongeurs and curettes (Fig. 2 lower right). The adjacent endplates are drilled, and the high-speed drill is used to extend the dissection into the adjacent VBs. The pedicle is removed with the drill and with Kerrison rongeurs. The lateral spinal canal is thus exposed early, before dissection of the posterior VB. With the dura clearly visible, the corpectomy is extended approximately 1.5 cm rostrally and caudally from the disc space. The depth of the corpectomy is approximately 3 to 3.5 cm medially from the lateral margin of the VB (Fig. 3 lower).

At this point, the drilling continues until only a thin shell of posterior VB and the PLL remains. The PLL often contains disc material and must be removed completely to

accomplish an adequate decompression. The PLL is divided with a reverse-angled curette and the remaining bone and ligament are pushed into the corpectomy defect and removed. The vector of force must always be into the corpectomy, away from the spinal canal. This portion of the resection is performed quickly because epidural venous bleeding can be significant. The bleeding is controlled with bipolar cautery after the decompression is completed. A nerve hook is used to probe for any remaining disc fragments. The final step is to drill appropriately sized troughs for placement of the rib autograft interbody strut (Fig. 3 lower).

The endothoracic fascia is replaced in its original position over the VB. If no pleural tears occurred closed-chest drainage is not necessary. A chest tube should be placed if significant intrathoracic air remains at the end of the procedure or if pleural leaks persist. Having the anesthesiologist deliver positive pressure can help to identify any pleural tears.

The ribs adjacent to the resection site are reapproximated with suture to reduce the chest wall deformity. To prevent the development of postthoracotomy neuralgia, it is critical to avoid ensnaring the intercostal nerves that run inferior to each rib. One way to ensure this is to drill a hole in the inferior rib through which the suture can be threaded.

As mentioned previously, exposure at the thoracolumbar junction (T11–L1) differs from higher levels in that

Fig. 3. Artist's drawings. *Upper:* Using a high-speed drill, the pedicle and adjacent endplates are removed, exposing the lateral dura. *Lower:* Rib autograft is placed after adequate decompression. (Used with permission from McCormick.)

the rib resection is two levels above the involved segment (a T-10 incision is made for a T-12 resection). The ribs in this region have a more caudal orientation than at higher levels. If the rib at the involved segment is resected, the upper ribs will overlie the surgically-treated level. The incision and rib resection are extended anteriorly by 2 to 4 cm. Exposure is also facilitated by centering the pathological level over the table break.

The rib is removed and the lateral endothoracic fascia, if present, is opened. The retroperitoneal and retropleural spaces are united by sharply dissecting the pleural surface of the diaphragm from the T-11 and T-12 ribs with periosteal dissectors. Medially, the detachment continues by freeing the arcuate ligaments from the psoas and quadratus muscles. Care must be taken to preserve the subcostal nerve as it runs laterally beneath the lateral arcuate ligament on the surface of the quadratus lumborum muscle. The ipsilateral crus of the diaphragm is divided on the VB, completing the mobilization of the hemidiaphragm. The proximal rib at the involved segment is resected as for higher levels. The psoas muscle attaches to the T-12 rib and may need to be released. At this point, discectomy or corpectomy proceeds as described above.

Closure involves reestablishment of the diaphragma-

tic attachments. The arcuate ligaments are sutured to the psoas and quadratus lumborum muscles. As for a thoracotomy performed at higher vertebral levels, the pleura is carefully inspected. Small tears are repaired using suture. A chest tube should be left if larger tears occurred or if there is significant air in the pleural space. The layers are closed using absorbable suture.

Procedure-Related Experience

Our series of retropleural approaches for thoracic discectomy or corpectomy consists of 57 patients treated over 7 years. Approximately 10% of patients required placement of a chest tube, which was generally removed within 36 hours. Patients without metastatic disease or Pott disease were often discharged by postoperative Day 4. Thoracolumbosacral orthoses were prescribed for a period of 3 to 6 months for patients with VB fracture, metastases, or Pott disease.

DISCUSSION

Retropleural thoracotomy provides the surgeon with the advantages of ventral exposure associated with the thoracic spine while potentially avoiding the morbidity of the standard transpleural thoracotomy. The retropleural is the most direct approach to the ventral spine; a smaller incision is needed compared with the standard thoracotomy; less retraction is required than for comparable exposure, which may help reduce postoperative pain and morbidity; the slightly more lateral trajectory avoids contact with the great vessels, which may otherwise partially obscure the disc space; and early identification of the ventral dura allows confident removal of disc and bone while protecting the neural elements.

The operative trajectory is suitable for resection of calcified or intradural discs. The surgeon has a sufficiently anterior view of the canal to free hardened disc fragments from the dura or to remove intradural material safely. A dural opening, intended or not, is relatively easy to repair primarily because of the direct operative route. With intact pleura, development of a CSF fistula is less likely than with the standard anterolateral thoracotomy. Because the integrity of the pleura is maintained, routine closed-chest drainage is not necessary. A chest tube on wall suction placed near a dural repair may draw CSF through the closure and contribute to the development of a fistula. Without a chest tube in place, the pleura and soft tissues of the thoracic cavity will tend to provide a relatively high resistance to CSF flow and help protect the dural closure. Chest tubes may also cause significant postoperative discomfort and inhibit early mobilization, leading to perioperative complications such as atelectasis and deep venous thrombosis.

While the surgical division of the sympathetic chain in the middle and lower thoracic region is generally without clinical sequelae, dividing the high thoracic sympathetic chain may result in a Horner syndrome. This approach should not be used above the T-3 level. Other techniques, such as a modified posterolateral thoracotomy or an extended cervical approach with resection of the manubrium and medial clavicle may be used to approach the uppermost thoracic segments.

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Posterolateral approaches, while traversing anatomy familiar to the neurosurgeon, do not easily yield direct exposure of the ventral or contralateral spinal canal. The exposure of the lateral canal and paraspinal region they provide is ideal for soft or lateral herniated discs. Access to central or hard discs usually requires retraction of the thecal sac and may involve blind retrieval of fragments. Maximizing ventral exposure with a posterolateral approach involves extending the musculocutaneous flap anteriorly, which may increase the patient's discomfort postoperatively. The foraminal dissection necessary to reach the anterior spinal canal places the segmental nerves and radiculomedullary artery at risk. Interruption of these structures may result in a deformity of the chest wall and spinal cord infarction, respectively.

In conclusion, the retropleural thoracotomy offers an alternative approach to the thoracic spine for disc disease; it provides the shortest direct surgical route to the ventral thoracic spine. Our experience has shown it to allow confident resection of central herniated thoracic discs with minimal postoperative morbidity. Patients are mobilized early and may be discharged after a short hospital stay.

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