Minimally Invasive Lateral Retropleural Thoracolumbar Approach: Cadaveric Feasibility Study and Report of 4 Clinical Cases

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Received, December 16, 2009.
Accepted, October 1, 2010.

BACKGROUND: Traditional anterior and posterior approaches to the thoracolumbar spine are associated with significant morbidity. In an effort to eliminate these drawbacks, minimally invasive retropleural approaches have been developed.

OBJECTIVE: To demonstrate the feasibility and clinical experience of a minimally invasive lateral retropleural approach to the thoracolumbar spine.

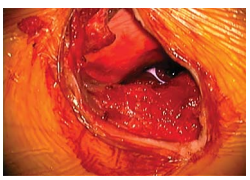
METHODS: Seven cadaveric dissections were performed in 7 fresh specimens to determine the feasibility of the technique. In each specimen, the lateral aspect of the vertebral body was accessed retropleurally, and a corpectomy was performed. Intraprocedural fluoroscopy and postoperative computed tomography were used to assess the extent of decompression. As an adjunct, 3 clinical cases of thoracic fractures and 1 neurofibroma were treated with this minimally invasive approach. Operative results, complications, and early outcomes were assessed.

RESULTS: In the cadaveric study, adequate exposure was obtained to perform a lateral corpectomy and to allow interbody grafting between the adjacent vertebral bodies. The procedures were successfully performed in the 4 clinical cases without conversion to conventional approaches. A pleural tear was noted in the first clinical case, and a chest tube was placed without any long-term sequelae.

CONCLUSION: Our early experience suggests that the minimally invasive lateral retropleural approach allows adequate vertebrectomy and canal decompression without the tissue disruption associated with posterolateral approaches. This approach may improve the complication rates that accompany open or endoscopic approaches for thoracolumbar corpectomies.

KEY WORDS: Lateral, Minimally invasive, Retropleural, Thoracolumbar

Neurosurgery 68[ONS Suppl 1]:ons32–ons39, 2011 DOI: 10.1227/NEU.0b013e318207b6cb



ONLINE DIGITAL VIDEO

The thoracolumbar junction poses an anatomic dilemma given the presence of the lower rib cage and the diaphragm. The anterior thoracic spine can be exposed through a variety of techniques. Multiple methods to access this area have been described, from a conventional open to a more minimally invasive approach. The technique used is often determined by the affected spinal level, pathological process, and surgeon preference. Posterior-based approaches include transpedicular, posterolateral costotransversectomy, and lateral extracavitary. Anterior-based approaches include anterolateral and laparoscopic thoracotomy, lateral transthoracic, and lateral retropleural thoracotomy.

Given the morbidity of open thoracic approaches and the steep learning curve of thoracoscopic approaches, posterolateral approaches have gained popularity by providing an oblique view of the spinal canal and avoiding morbidities associated with entry into the chest. Despite the advantages of the lateral extracavitary approach, there are still several drawbacks such as substantial blood loss and

ABBREVIATION: ASIA, American Spinal Injury Association; **MAST LRPA,** minimal-access surgical technique lateral retropleural approach

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postoperative pain resulting from the extensive muscle dissection.

With recent advances in minimal-access technology, many spinal procedures are being performed with an emphasis on minimizing tissue damage and blood loss. The demonstrated benefits of these new procedures include less tissue dissection, decreased postoperative pain, reduced length of hospital stay, and earlier mobilization.[1-3] The feasibility of these approaches has been demonstrated through a variety of posterolateral and anterolateral techniques.[4-7]

The retropleural minimal invasive approach to the thoracolumbar junction is considered a variant of the lateral retropleural thoracotomy.[8] However, it combines many of the positive attributes of both anterolateral transthoracic approaches and the lateral extracavitary approach. It affords the surgeon the ability to remain outside the pleura while achieving a ventral decompression of the dural sac. This is particularly important when dealing with centrally located lesions such a central disk herniation. In these cases, a greater angle of ventral approach provides a safer operative exposure.

The advantage of having lateral exposure of the thoracolumbar spine is that it allows the surgeon to visualize the thecal sac during the approach to the abnormality. The surgeon will then have control of both the thecal sac and pathology, compared with more ventral approaches in which the thecal sac is not visualized until the disease process is resected. On the other hand, in posterior approaches, the dural sac is visualized first while the abnormality is partially visualized and/or indirectly decompressed.

We describe our early experience with a minimally invasive lateral retropleural approach using a tubular expandable retractor to the thoracolumbar junction. Technique, pitfalls, and early postoperative results are discussed.

MATERIALS AND METHODS

Study Design

Seven fresh cadaveric dissections were performed at the thoracolumbar junction to determine the feasibility of the technique. With the cadavers in the lateral decubitus position and under fluoroscopic guidance, thoracic corpectomies were performed with an expandable tubular retractor system under magnification. The pleura and dural sac were examined for evidence of injury. Intraprocedural fluoroscopy was used to assess the extent of the corpectomy. In addition to the cadaveric dissections, 4 patients underwent the minimally invasive lateral retropleural approach. One patient underwent removal of a benign tumor (neurofibroma), and 3 patients underwent a 1-level thoracic corpectomy and reconstruction secondary to fractures. Preoperative and postoperative computerized tomography (CT) scans were obtained to evaluate the extent of spinal canal decompression and vertebral body resection. In the case of the tumor, preoperative and postoperative magnetic resonance imaging was also obtained to assess adequate resection.

Surgical Technique

In a lateral decubitus position and under fluoroscopic guidance, a 6-cm-long oblique incision (following the trajectory of the rib at the index level) was made at the midaxillary line. In all cases, the side of the approach was chosen according to the vertebral level and the location of the abnormality. Approximately 5 cm of the rib immediately overlying the target level was dissected subperiosteally from the underlying pleura and neurovascular bundle and removed. The portion of resected rib was set aside for use as autograft. Once the parietal pleura was exposed, the plane between the endothoracic fascia and the pleura was developed. The pleura was then mobilized anteriorly along with the diaphragm bluntly with a sponge stick until the lateral side of the vertebral body and adjacent disks were exposed. Sequential tubular dilators were then inserted. The aorta and hemiazygos vein were retracted anteriorly. An expandable tube retractor system was then inserted over the largest dilator and secured with a flexible table-mounted arm assembly (Figure 1). Under magnification using surgical loupes (× 2.5 magnification), the rib head and the costovertebral ligaments at the corresponding level were removed. The segmental vessels were ligated as proximally as possible. Before the corpectomy was performed, the dura was exposed by removing the pedicle with rongeurs and a high-speed drill as a guide to the location and proximity of the spinal canal. The intervertebral disks above and below the vertebral body of interest were removed. Osteotomes were used to delineate the area of corpectomy. Then, the vertebral body was resected through the use of a combination of a drills, curettes, and rongeurs according to the goals of surgery. A thin layer of bone on the ventral and contralateral sides of the body and the anterior longitudinal ligament were preserved to protect mediastinal and thoracic structures. For ventral reconstruction, we placed expandable titanium cages (Figure 2) (Obelisk, Ulrich Medical, Ulm, Germany) and bone autograft (rib). Spinal instrumentation was completed by ventrolateral plate/screws fixation through the expandable tube retractor and or percutaneous posterior pedicle screw/rod. In the event of the pleura being violated, a chest tube would be placed (see Video 1, Supplemental Digital Content 1, http://links.lww.com/NEU/A366, which demonstrates an intraoperative view of the retropleural approach).

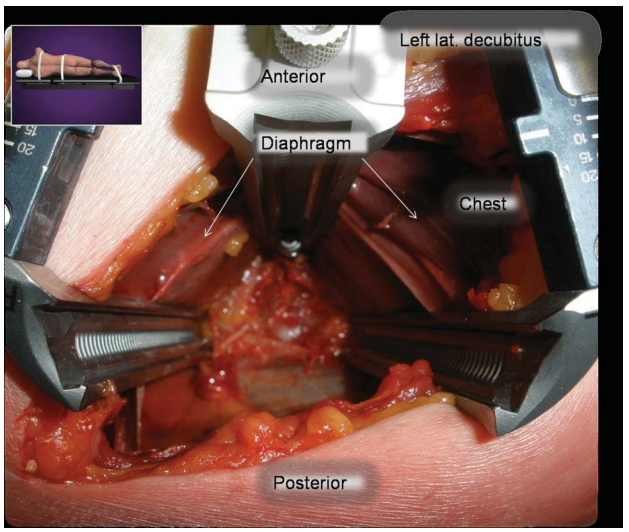

FIGURE 1. *Photograph of a cadaveric specimen in the left lateral decubitus position depicting the placement of the expandable retractor in relation to the diaphragm using the retropleural approach.*

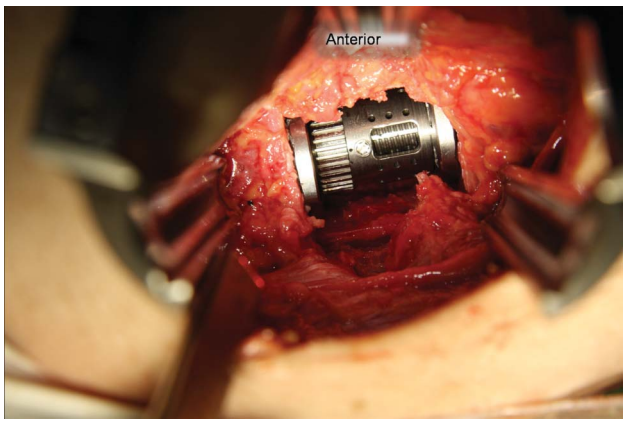

FIGURE 2. *Photograph of a cadaveric specimen in the left lateral decubitus position status after a corpectomy with canal decompression and placement of an expandable titanium cage using the lateral retropleural approach.*

CLINICAL CASES

Patient 1

A 36-year-old man presented with pain and progressive paraparesis secondary to an L1 osteoporotic pathological fracture resulting from chronic steroid use for the treatment of a brain glioma. This patient underwent a minimal-access surgical technique lateral retropleural approach (MAST LRPA) for an L1 corpectomy and placement of an expandable titanium mesh cage with vertebral body plate/screw, vertebral cement augmentation, and bilateral percutaneous pedicle screw/rod fixation. Bone autograft from the rib was used to promote arthrodesis. The patient showed neurological improvement postoperatively but died of complications related to his brain glioma 9 months after surgery. No imaging beyond the perioperative period was obtained. The estimated blood loss was 600 mL, and the operating time was 6 hours. During the surgery, a pleural tear was noticed, so a chest tube was placed as a precaution. The postoperative course was otherwise uneventful with no sequelae.

Patient 2

A 53-year-old man presented with severe back pain, hip flexion weakness, L1/L2 dermatomal sensory deficit, and urinary retention after a flexion compression trauma from a fall (American Spinal Injury Association [ASIA] C). Radiographs and CT revealed an L1 burst fracture with retropulsed bone fragments into the spinal canal (Figure 3). The patient underwent an MAST LRPA L1 corpectomy and T12-L2 arthrodesis with a titanium expandable cage (Obelisk), rib autograft, T12-L2 ventrolateral plate instrumentation, and posterior percutaneous pedicle/rod screws (Figure 3). After 12 months of follow-up, the patient had significant reduction in pain and significant neurological recovery (ASIA D). The estimated blood loss was 550 mL, and the operative time was 7 hours. There were no perioperative complications.

Patient 3

A 48-year-old man presented with a medical history significant for scoliosis and neurofibromatosis type 1 complaining of progressive debilitating pain in the T11-12 dermatomes on the left chest. CT scan and magnetic resonance imaging showed a retropleural neurofibroma located in the T11-12 neuroforamen. He underwent an MAST LRPA resection of the tumor (Figure 4). The patient had an uneventful postoperative course. The estimated blood loss was 150 mL, and the operative time was 2 hours. There were no perioperative complications.

Patient 4

A 54-year-old man presented with severe back pain after a motor vehicle accident (ASIA E). Radiographs and CT revealed a T6 compression and T11 burst fracture with retropulsed bone fragments into the spinal canal (Figure 5). The patient underwent an MAST LRPA for a thoracic T11 corpectomy and T10-12 arthrodesis with a titanium expandable cage (Obelisk), rib autograft, and T10-12 ventrolateral instrumentation with a lateral plate (Figure 5). After 3 months of follow-up, the patient had significant reduction in pain, and there were no signs of hardware-related complications. The estimated blood loss was 500 mL, and the operative time was 5 hours. There were no perioperative complications.

RESULTS

Cadaveric Study

With a midaxillary fluoroscopy-guided incision and a partial rib resection at the corresponding level, adequate exposure was obtained to place the expandable tube retractor system, to perform a lateral corpectomy (pedicle to pedicle), and to allow interbody grafting, instrumentation, and correction of the deformity between the adjacent vertebral bodies, regardless of the level at which it was performed. The pleura, dura mater, and intrathoracic contents were not violated on any of the specimens. Furthermore, the pleura and the diaphragm between the retractor blades protect and keep the lungs and the intrathoracic structures out of the surgical field. At the L1 level, the retropleural space was easily connected to the retroperitoneal cavity.

Clinical Cases

The procedures were successfully performed in the 4 clinical cases without requiring conversion to conventional open approaches (Table). The average estimated blood loss for the 4 cases was 460 mL; the average operating time was 5 hours. The mean follow-up was 4 months with a range of 2 to 6 months. Single lung ventilation was not necessary in any case. No postoperative complications were encountered. However, a chest tube was placed in 1 patient in whom a pleural tear was identified intraoperatively. This event has not influenced us in abandoning the retropleural approach. In all cases, postoperative images demonstrated adequate decompression, deformity correction,

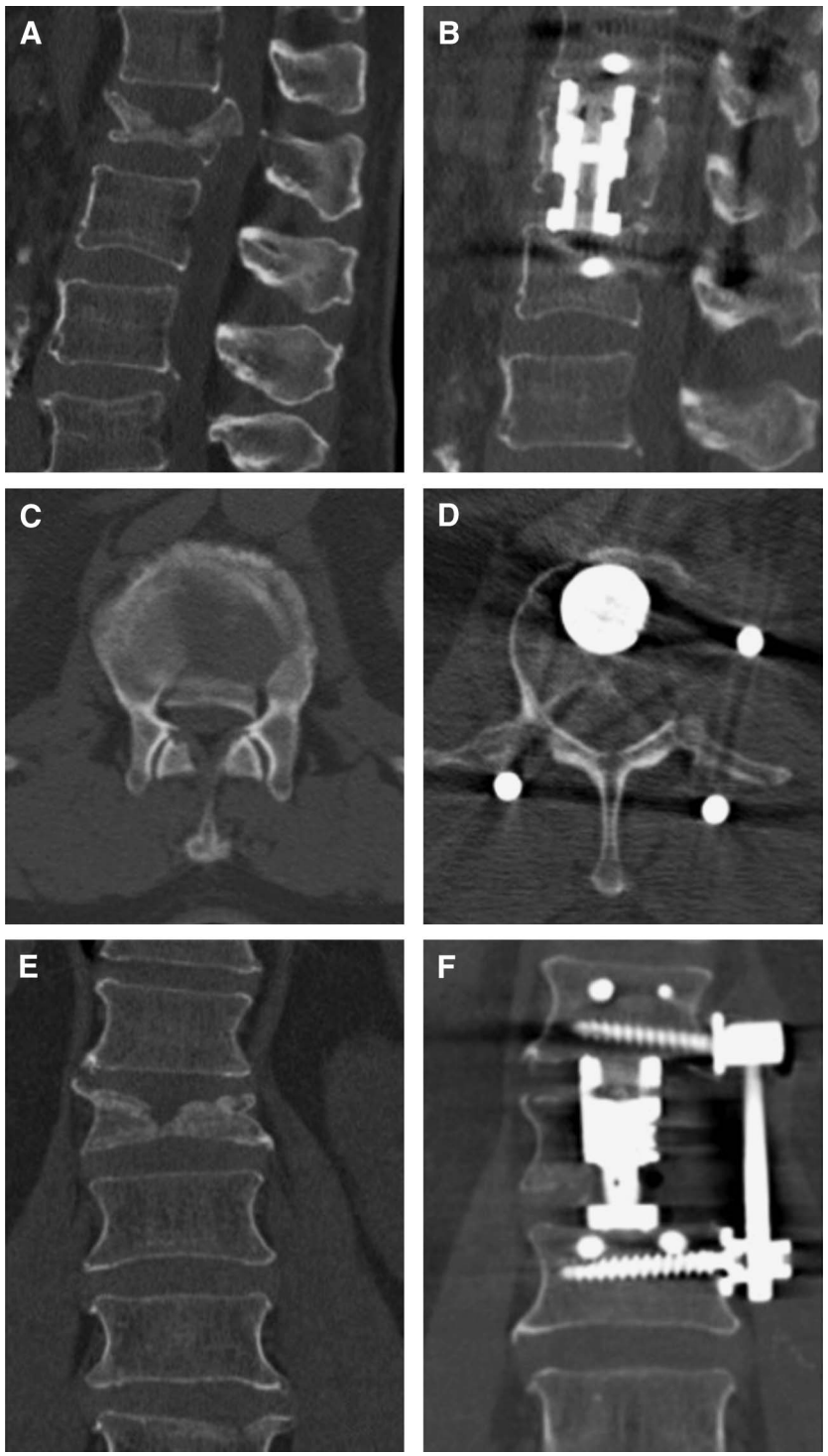

FIGURE 3. *Preoperative computed tomography images in the sagittal (A), axial (C), and coronal (E) planes illustrating a traumatic burst fracture of L1. Postoperative computed tomography images in the sagittal (B), axial (D), and coronal (F) planes.*

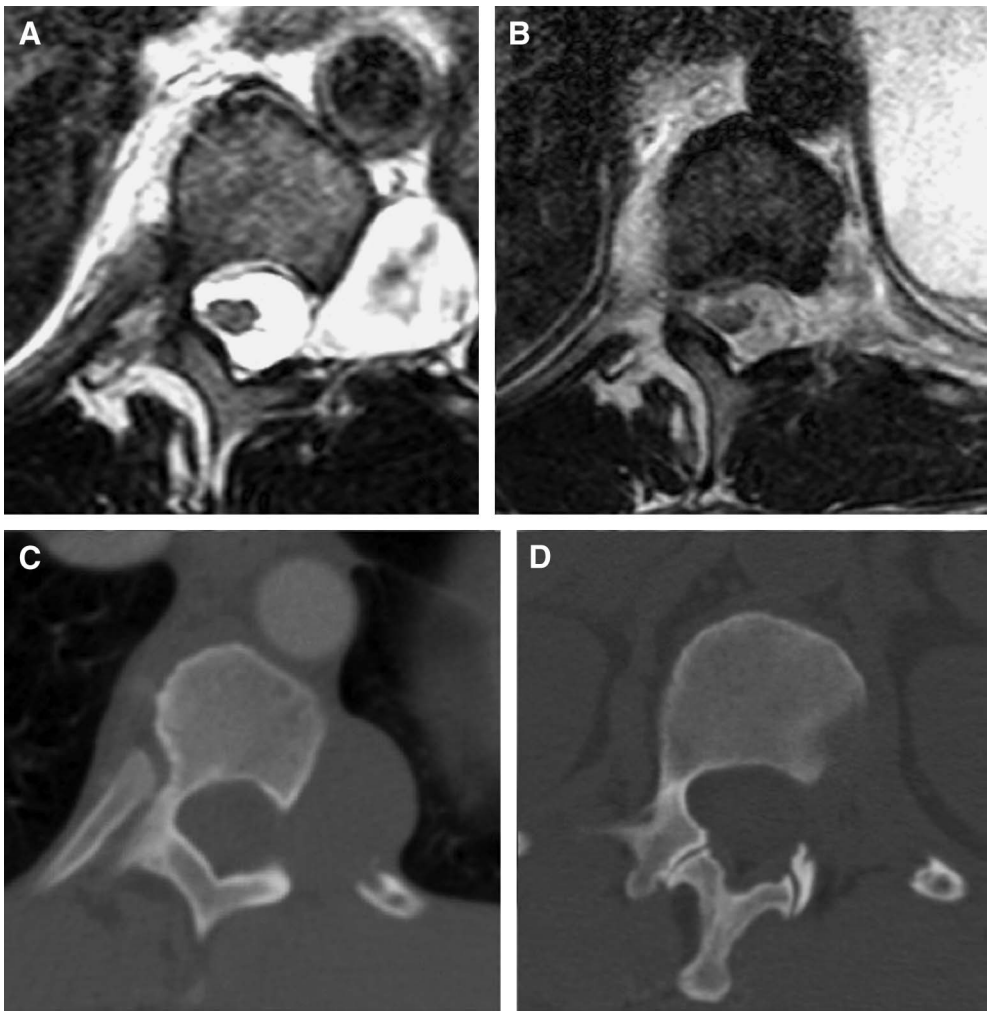

FIGURE 4. *Axial preoperative (A) and postoperative (B) magnetic resonance imaging illustrating a T11-12 neurofibroma resected through the minimally invasive lateral retropleural approach. Axial preoperative (C) and postoperative (D) computed tomography images.*

and satisfactory placement of the interbody cages and instrumentation. The patients with preoperative neurological symptoms demonstrated clinically significant improvement.

DISCUSSION

Surgical reconstruction techniques for disorders of the thoracolumbar spine have undergone a dramatic evolution over the last 15 years. Acute instability with structural damage to the anterior load-bearing spinal column and posttraumatic deformity represent the most frequent indications for surgery. Anterior column reconstruction of the thoracolumbar spine to treat spinal trauma, metastasis, and inflammatory lesions has become increasingly popular because of the unfavorable results obtained from posterior-only approaches.[9-11] Surgical decompression of ventrally located cord-compressive lesions and the durability of kyphosis correction in patients with significant ventral column destruction from a solely posterior approach have been unsatisfactory.[8,12] The location of this section of the spine, in the border area between the thoracic and abdominal cavities, makes it necessary in most cases to partially detach the diaphragm to expose the operative site and to provide access to the retroperitoneal section of the thoracolumbar junction. Multiple approaches to access this area have been described.[6-8,13,14] The affected spinal level, pathological process, and surgeon preference often determine the technique used.

Anterior-Based Approaches

Anterior transthoracic approaches have long been established in the management of many pathological conditions of the

FIGURE 5. *Preoperative computed tomography images in the sagittal (A), axial (C), and coronal (E) planes illustrating a traumatic burst fracture of T11. Postoperative computed tomography images in the sagittal (B), axial (D), and coronal (F) planes. See also Video 1 (Supplemental Digital Content 1, http://links.lww.com/NEU/A366), which demonstrates an intraoperative view of the retropleural approach.*

anterior thoracolumbar spine.[15] Anterior approaches provide adequate access to the ventral aspect of the spine and allow decompression without the associated risks of spinal cord or nerve root manipulation.[9-11] However, a thoracotomy requires a large skin incision, lung and rib retraction, and muscle dissection. These all can contribute to postoperative pulmonary dysfunction (such as pulmonary contusions, atelectasis, pleural effusions, hemothorax, and chylothorax), as well as significant perioperative

TABLE. Summary of Patients

Patient	Age, y	Sex	Pathology	Procedure	Length of Stay, d
1	36	Male	Osteoporosis	L1 corpectomy	8
2	53	Male	Trauma	L1 corpectomy	7
3	48	Male	Tumor	T11-12 tumor resection	3
4	54	male	Trauma	T11 corpectomy	7

and postoperative pain from extensive rib resection.[12,16,17] Thoracotomy-associated major complications occur in 11% to 11.5% of patients, tend to extend hospitalizations, and augment medical resource use.[12,17] To reduce the morbidity associated with a thoracotomy, less invasive thoracoscopic techniques have been developed and refined for performing a thoracic corpectomy and reconstruction.[18-20] Thoracoscopy is capable of producing the same exposure as the transthoracic route without the need for a large incision or rib resection. Although the incidence of complications related to open thoracotomy is considerably lower, there is still a significant decrease in vital capacity by up to 30%.[21-23] Other reported complications include transient intercostal neuralgia, postoperative atelectasis, pneumothorax, pleural effusions, and hemothorax.[18,24,25] Additionally, the learning curve is steep for thoracoscopic procedures. Specialized training with instructional and laboratory teaching is necessary to master this technique.

Posterior-Based Approaches

The posterolateral approaches (lateral extracavitary and costotransversectomy), first introduced by Capener[26] and later modified by Larson et al,[14] have become popular and are frequently used routes to access the spine in multiple different areas. These approaches avoid the morbidities associated with entry into the chest and provide adequate exposure for neural decompression, corpectomy, vertebral reconstruction, and simultaneous posterior spinal fixation.[13,27] However, this procedure requires extensive tissue dissection and typically results in copious amounts of blood loss. If uncontrollable bleeding occurs, the procedure cannot be easily converted to an anterior-based approach. To decrease morbidity, a minimally invasive application of this technique has been developed.[5,6] The disadvantages of this approach include an oblique view of the dural elements, a limited ability to correct deformities, a need for sectioning of nerve roots, and an inability to effectively address lesions involving > 1 level.

Lateral Retropleural Approach

In an effort to eliminate the drawbacks related to thoracotomy or the extensive tissue dissection associated with the posterolateral approaches, the retropleural thoracotomy was developed and popularized by McCormick.[8] Unlike posterolateral approaches, a retropleural thoracotomy permits direct view of the dural elements and allows the surgeon to expose the lateral canal without the need to dissect or potentially sacrifice the intercostal nerve or intraforaminal radiculomedullary artery.[19,28] In contrast to the anterolateral thoracotomy, the dissection remains extrapleural or retroperitoneal and potentially poses less risk of injury to the aorta, vena cava, and sympathetic plexus while decreasing the chance for developing a duropleural cerebrospinal fluid fistulae.[8,16,29] If uncontrollable bleeding or a large dural tear occurs, the procedure can easily be converted to an open approach. However, this approach requires a relatively large incision and extensive rib resection.[8]

Our minimally invasive application of this approach is a technical variation of similar approaches to decrease the morbidity associated with the lateral thoracotomy.[7,8] Although nonexpansible structural grafts can be used from this approach, anterior reconstruction is greatly facilitated by the use of expandable cages. In our experience, the amount of kyphosis correction achieved is equivalent to that achieved with open procedures. One drawback of the minimally invasive retropleural approach to the thoracic and thoracolumbar spine is that if posterior instrumentation is required, a second incision must be made. At the thoracolumbar junction, when the lateral approach is used, there is a long working distance in a relatively narrow working space. Consequently, the operative tools typically used may not be long enough to perform the procedure in some patients. Retropleural and retroperitoneal dissection may not be feasible after a previous ipsilateral thoracotomy or retroperitoneal approach. Patients with osteomyelitis of the spine and spinal metastases can have marked paraspinal pleural reactions with adhesive thickening of the parietal pleura and infiltration of the pleura by tumor or inflamed fibrous tissue.

As with all new techniques and technologies associated with minimally invasive spine surgery, a steep learning curve is associated with this approach. This advanced application of the minimally invasive lateral approach is technically demanding and requires experience with minimally invasive techniques, including working through a long narrow corridor. Longer follow-up with a larger number of patients is required to assess the efficacy of the procedure.

CONCLUSION

This minimally invasive lateral retropleural approach to the thoracolumbar spine for corpectomy and diskectomy allows effective decompression of the spinal canal and ventral decompression of the thoracolumbar spine without the associated morbidity related to the traditional anterior or posterior approaches. This method provides an approach trajectory similar to that obtained with the lateral retropleural thoracotomy while dramatically reducing the muscular dissection needed. This approach may improve the complication rates that accompany open or endoscopic approaches for a thoracic corpectomy. This approach to the thoracic and thoracolumbar spine should be in the armamentarium of spine surgeons who treat complex spinal disorders.

Disclosure

Dr Uribe is a paid consultant for Nuvasive, Inc. The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENTS

The authors describe their experience in performing a corpectomy and stabilization through a novel minimally invasive lateral retropleural thoracolumbar approach. From the clinical and radiographic information provided, it appears as though this technique can be performed safely by experienced surgeons. The preliminary results appear to be similar to those of more traditional procedures, yet a larger study group will be needed before equivalence can be determined. This is a significant leap from more straightforward minimally invasive procedures, and a definite learning curve exists. The authors performed this technique in 7 cadavers before attempting it in a clinical case.

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Los Angeles, California

In this article, Dr Uribe and colleagues describe a modified minimally invasive approach to the thoracolumbar region. The approach uses a 6-cm-long oblique incision along the trajectory of the rib at the midaxillary line. This approach allows a direct view of the dural elements without endangering the intercostal nerve or the intraforaminal radiculomedullary artery. It also potentially poses less risk of injury to the aorta, vena cava, and sympathetic plexus. The retropleural nature of the procedure decreases the recovery time associated with the stress of lung retraction.

Dr Uribe and colleagues demonstrate the procedure successfully in 7 cadaveric studies and 4 clinical cases. In the 4 clinical cases, none required conversion to an open procedure, and only 1 required a chest tube to address a pleural tear. These results are positive enough to attempt this type of procedure in more cases in the future. The benefits in terms of blood loss and recovery time are potentially great, and the procedure may significantly reduce the number of open procedures performed to access the thoracolumbar region.

This well-written and carefully considered article introduces an important modification of a minimally invasive approach. All such approaches should be considered by surgeons before deciding on an approach to use in a particular case.

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