Minimally Invasive Thoracolumbar Corpectomy and Reconstruction

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Minimally invasive surgical approaches have been advocated to approach ventrolateral thoracolumbar pathology. This article describes our technique for performing minimally invasive surgical thoracolumbar corpectomy and reconstruction. Twenty-five consecutive patients at a single institution were treated between 2006 and 2010 for a variety of diagnoses including tumors, infections, and trauma. Treatment variables, including operating time, estimated blood loss, number of levels treated, and complications, were collected, as were visual analog scale (VAS) scores for pain.

Surgical times (mean, 188.5 minutes) and blood loss (mean, 423 mL) reflect a significant improvement over standard open corpectomy procedures. More than 60% of patients did not need blood products after the corpectomy procedure because substantial blood loss encountered during an open exposure to the spine was obviated. Similarly, operative times and anesthetic load was minimal enough for >80% of our patients to be extubated immediately after the corpectomy procedure. A 62% decrease in self-reported VAS scores was observed. No wound complications or radiographic evidence of implant subsidence or failure were observed at last follow-up.

The advantages of the minimally invasive approach for corpectomies of the thoracolumbar spine were that an access surgeon was not needed; tissue dissection and surgical exposure were reduced, improving VAS scores postoperatively; and blood loss and operative times were minimized, preventing hemodynamic deterioration in these complex cases. Corpectomies may be performed in this fashion safely, with excellent pain relief and without many of the morbidities and difficulties associated with conventional open procedures.

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Figure: Exposure of tumor (A) and insertion of an expandable cage after complete T8 corpectomy with tumor resection (B). Note screws in T7 and T9.
Corpectomy and reconstruction of the thoracolumbar spine are indicated for several clinical scenarios, including management of unstable burst fractures,1–3 vertebral osteomyelitis,4,5 and vertebral body tumors.6 Access to the anterior thoracic spine may include thoracotomy-based lateral extracavitary, retropleural, or transthoracic approaches. An advantage to these approaches is visualization of the anterior thoracic spine; however, disadvantages include blood loss, pleural effusion, hemothorax, atelectasis, postoperative intercostal neuralgia, and post-thoracotomy pain secondary to rib resection.7–11 Similarly, the lumbar spine may be approached through a direct anterior approach that affords excellent visualization of the diseased segment, but significant complications are associated, including blood loss, injury to the great vessels, retrograde ejaculation (for the L4-S1 segment), and autonomic dysfunction.7–11

Recently, minimally invasive surgical approaches have been advocated to approach ventrolateral thoracolumbar pathology. Detractors of minimally invasive surgical argue that this approach has expensive instrumentation and a significant learning curve,10 and, in cases of trauma, may lead to an emergent conversion or an open approach.10,12–14 Proponents maintain that minimally invasive surgical approaches to the thoracolumbar spine, even in complex cases, have demonstrated promise using familiar surgical techniques and direct visualization with minimal insult to the soft tissue.15–22

Several reports in the literature detail the use of lateral minimally invasive approaches to thoracolumbar pathology (degenerative deformity and trauma)17,23; however, a paucity of evidence exists regarding using this approach for corpectomy and reconstruction. The purpose of this study is to report our technique and early results of patients treated with a minimally invasive surgical thoracolumbar corpectomy and reconstruction for a variety of complex diagnoses.

**Materials and Methods**
Twenty-five consecutive patients at a single institution were treated with minimally invasive surgical corpectomies between 2006 and 2010 for a variety of diagnoses, including tumors, infections, and trauma. Treatment variables, including operating time, estimated blood loss, number of levels treated, and complications, were collected, as well as visual analog scale (VAS) scores for pain.

**Surgical Technique**
After successful intubation, patients were placed in a lateral decubitus position with the side of interest upright. A lateral fluoroscopic image was used to localize the pathologic vertebral body. The spine was then prepped and draped in the standard surgical fashion. Intraoperative fluoroscopy was used to confirm the correct level. Real-time neuromonitoring was used throughout each case, with stimulated monitoring used during passage through the psoas muscle (where necessary), retractor expansion, and instrument implantation.

In the thoracic spine (T5–T11), a bronchial blocker was used. The lung was only deflated for the short period of time needed to dock dilators. A lateral retropleural approach was then used, with an incision ≤3 inches and an approximately 2 to 3 cm rib resection. For T12 and L1 cases, an extrapleural subdiaphragmatic transthoracic approach was used. Thoracic nerve roots were not sacrificed.

Accessing the anterior column in the lumbar spine (L2–L5) followed the same retroperitoneal approach as extreme lateral interbody fusion (XLIF; NuVasive, Inc, La Jolla, California), which has been described previously.23 However, a modification was used in which the anterior border of the psoas was identified and swept posteriorly, placing the tube dilators anterior to the muscle belly, avoiding potential neurologic complications.

A combination of tube dilations preceded docking of an expandable retractor on the anterior spinal column. A thorough discectomy was performed at the appropriate levels in all cases. After coagulation of segmental vessels, corpectomy was performed using a high-speed burr. When relevant, fragments or pathology was removed until adequate decompression of the spinal canal was achieved. Intraoperative fluoroscopy was used to confirm the extent of the corpectomy.

Reconstruction of the anterior vertebral body was performed using an appropriately sized expandable titanium cage (or a strut allograft in selected cases). Rib autograft was packed into the cage with either a β-tricalcium phosphate ceramic or, in cases of infection or trauma, recombinant human bone morphogenetic protein-2 (INFUSE; Medtronic Sofamor Danek, Memphis, Tennessee) and impacted into place using anteroposterior and lateral fluoroscopic imaging. INFUSE has been approved by the US Food and Drug Administration for anterior lumbar interbody fusion in conjunction with a threaded lordotic cage; however, its use here is considered off label.

Supplemental internal fixation included either anterolateral rod and screw constructs, posterior (open or percutaneous) pedicle-screw fixation, or both anterolateral and posterior pedicle screw fixation. A rubber catheter was placed deep into the wound and placed on low wall suction. A purse-string suture was used to close over the drain. Based on pulmonary and hemodynamic stability, the patient was either extubated or remained intubated.

**Results**
Twenty-five patients were identified with a variety of diagnoses (tumors, n=10; infection, n=5; burst fractures, n=9; disc herniation, n=1) (Table 1). Mean age at operation was 49.7 years (range, 17–71 years), mean body mass index was 29.8 kg/m² (range, 15–68 kg/m²), and mean follow-up was 5.1 months (range, 1–17 months). Fourteen (56%) patients were American Society of Anesthesiologists (ASA) grade ≥3 (Table 2). Operating time, estimated
blood loss, and mean number of corpectomies per patient were 188.5 minutes (range, 75-373 minutes), 423 mL (range, 50-1600 mL), and 1.2 (range, 1-3), respectively. The mean preoperative hemoglobin was 11.2 g/dL (range, 9-15 g/dL), and the mean lowest postoperative hemoglobin was 8.7 g/dL (range, 7-12 g/dL).

Sixteen (64%) patients did not require blood products postoperatively. Twenty-one (84%) patients were extubated immediately postoperatively. There were 13 anterior-alone reconstructions and 12 staged operations with supplemental posterior instrumentation. No perioperative complications were noted. No wound complications were observed. The 2 patients with tumors died during the study period as the result of metastases (>3 months after initial surgery). No radiographic evidence of implant subsidence or failure was observed at last follow-up. An average 62% decrease in self-reported VAS scores was found at last follow-up.

The indications to perform an open vs minimally invasive approach to a thoracolumbar corpectomy continues to be a subject of debate. Using a thoracotomy-based approach affords excellent visualization of the ventral spinal column, allowing a thorough decompression without risking spinal cord manipulation.

The disadvantages of a thoracotomy are that it requires a large skin incision, excessive lung and rib retraction, and intercostal muscle dissection, which can cumulatively contribute to poor postoperative pulmonary function. Complications of this approach include atelectasis, pleural effusions, hemothorax, chylothorax, and significant postoperative pain from the rib resection. Major complications directly attributable to the thoracotomy occurred in up to 12% of patients, leading to prolonged hospitalization and excessive use of medical resources.

Based on these data, attempts have been made to develop a minimally invasive approach to accessing the ventrolateral thoracolumbar spine. The introduction of the lateral transpsoas approach using an expandable retractor (XLIF) has made access to the retroperitoneal lumbar spine less morbid, with excellent results noted in patients requiring anterior interbody fusion for predominantly degenerative conditions.

Rodgers et al reported 100 patients undergoing interbody fusions through a transpsoas approach for adjacent-level degeneration after a primary fusion. Their results revealed short-term improvement in pain scores, decreased length of hospital stay, and low complication rates. Avoidance of the posterior scar and revision instrumentation afforded by the lateral approach was also stressed as a reason for good clinical outcomes in this cohort.

Another study by Oliveira et al reported the fusion rates in a small patient series (N=15). They described short operative times (average, 67 minutes), minimal blood loss (average, 50 mL) and short hospital stay (range, 12-48 hours). The complication rate was 6.7%, with patients experiencing significant improvement in pain and function scales at all postoperative visits.

Similarly, Ozgur et al reported patients with predominantly degenerative conditions with a 2-year follow-up. In 62 patients (a total of 113 levels, with up to 5 levels in 1 patient), clinical results were deemed excellent at 2 years, with radiographic evidence of fusion in 91% of patients.

Dakwar at al reported 25 adult patients with deformities who were treated with interbody fusion using a direct lateral transpsoas approach and showed that...
<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, y</th>
<th>Pathological Diagnosis</th>
<th>Procedure</th>
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</tr>
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<tbody>
<tr>
<td>1</td>
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<td>Metastatic lung carcinoma, T6 vertebral body fracture, T6 corpectomy</td>
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<td>Epidural abscess with osteomyelitis T12-L1 and L4-L5 neurologic deficit</td>
<td>Corpectomy T12-L1 with ASF T11-L2 with Corpectomy L4 (separate incision) followed by PSF L4-L5</td>
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Abbreviations: ASA, American Society of Anesthesiologists; ASF, anterior spinal fusion; PSF, posterior spinal fusion.
operative times and blood loss were minimal despite having multilevel procedures. Complications reported in that series were mostly minor. Other authors have shown similar results in the management of adult degenerative and adult deformity patients requiring multilevel anterior procedures.29-31

We used the same minimally invasive surgical approach to perform corpectomies on patients with complex spinal disorders, including tumor (Figures 1-4), trauma, and infection in the thoracolumbar spine. In our series of 25 patients, >50% had an ASA grade of ≥3, indicating the physiologic complexity of these cases. A standard thoracotomy-based approach for the thoracic lesions and anterior open lumbar approaches would have led to increased surgical morbidity. We believe that our surgical times (mean, 188.5 minutes) and blood loss (mean, 423 mL) reflect a significant improvement over standard open corpectomy procedures in this subset of patients.

More than 60% of patients did not need blood products after the corpectomy procedure because substantial blood loss encountered during an open exposure to the spine was obviated. Similarly, operative times and anesthetic load were minimal enough for >80% of our patients to be extubated immediately after the corpectomy procedure.

It must be noted that, unlike degenerative or deformity patients treated in an elective manner, our patients necessitated a semi-urgent operative procedure for neural decompression, pain relief, and structural reconstruction. A 62% decrease in self-reported VAS scores was observed,
indicating that even in this challenging subset of patients, a minimally invasive approach to corpectomy and reconstruction allows significant pain relief.

We believe the advantages of the minimally invasive approach for corpectomies of the thoracolumbar spine are as follows: an access surgeon is not needed; tissue dissection and surgical exposure are reduced and improve VAS scores postoperatively; and blood loss and operative times are minimized, which prevents hemodynamic deterioration in these complex cases.

REFERENCES


