8 Minimally Invasive Thoracoscopic Approach to the Anterior Thoracic Spine

Meic H. Schmidt

Introduction

Anterior approaches to the thoracic spine and the thoracolumbar junction have been progressively developing from traditional, open approaches to minimally invasive techniques. The use of endoscopic spine surgery has significantly expanded since its first description in the literature in the 1990s. Thoracoscopic surgeries have become safe and time efficient with comparable and better complication rates and outcomes than open approaches [1]. Common applications of thoracoscopy in spine surgery are anterior release for scoliosis, thoracic disc herniation, and corpectomy for traumatic fracture reconstruction. In this chapter, we discuss the role of thoracoscopic surgery in the management of metastatic spine disease.

Equipment for Thoracoscopic Surgery

Video Imaging System

One of the most important aspects for successful endoscopic surgery is to have high-quality images of the surgical field. The new high-definition video technology that is currently available has revolutionized image quality. A high-intensity xenon light source is typically connected to a 30-degree, 10-mm endoscope. This image is transmitted via a high-definition camera to two or three flat-screen monitors.

Endoscopic Tools

Tools for thoracoscopic surgery typically need to be long enough to allow for a three-point anchoring surgical technique. In addition, the tools should have depth markings and need to fit through 10-mm ports. Each port has a flexible black, threaded trocar with an inner diameter of 11 mm. It is important that the trocars are black to minimize light reflection from the camera. Similarly, all thoracoscopic tools should have nonreflective surfaces.

The harmonic scalpel is another invaluable tool for endoscopic surgery, although it is not commonly used in other spine surgeries. The harmonic scalpel cuts and coagulates by transferring mechanical energy to tissues. It therefore minimizes thermal injury and smoke that can interfere with visualization via an endoscope.

Endoscopic diaphragmatic retraction becomes necessary the closer one operates to the thoracolumbar junction. The diaphragm on the left side typically inserts along the lateral surface of the spine at the T12/L1 disc space. To create the working space, one must carefully retract

M. H. Schmidt
Brain and Spine Institute, Department of Neurosurgery, Westchester Medical Center at the New York Medical College, Valhalla, NY, USA
e-mail: meic.schmidt@wmchealth.org

D. M. Sciubba (ed.), *Spinal Tumor Surgery*, https://doi.org/10.1007/978-3-319-98422-3_8

the diaphragm, thereby expanding the costodiaphragmatic recess for surgery. Incising the diaphragm to expose the retroperitoneal space is necessary for placement of screws into the upper third of L1 or for L1 corpectomy with placement of screws into the top of L2.

For the corpectomy, it is recommended that one uses osteotomes with depth markings. Osteotomes allow for efficient vertebrectomies with minimal splattering of irrigation and blood, which can interfere with the optics on the endoscope. We do occasionally use an endoscopic drill (Midas Rex) to drill off the rib head or even out the endplates.

Endoscopic Spinal Reconstruction

Typically, either of two spinal implants can be placed for thoracoscopic spine surgery for metastatic disease: a vertebral body replacement (expandable cage) or an anterior lateral plating system. Expandable cages have become the preferred implant after corpectomy for metastasis. They are usually made from titanium alloy to minimize any postoperative imaging artifact. They can be placed via a small opening and expanded between the two endplates. Anterior lateral plates are commercially available from several companies. The MACS TL plate (Aesculap, Germany) is preferred for thoracoscopic surgery because it was designed for that purpose and has several features that make endoscopic implantation more efficient.

Preoperative Considerations

Patients are evaluated with standard spine imaging, including computed tomography (CT) and magnetic resonance imaging (MRI), and with anterior/posterior and lateral radiographs of the chest to evaluate for pleural effusion, fibrinous membranes, or dense adhesions in the pleural space.

Intravenous high-dose steroids are used in patients with symptomatic spinal cord compression or myelopathy. In addition, we routinely ask for endovascular embolization for most vascular metastasis.

Single-Lung Ventilation

Good single-lung ventilation is crucial for thoracoscopic spine surgery. It is best achieved with a double-lumen endotracheal tube. In smaller patients, an endobronchial blocker can be used. It is important to note that thoracoscopic spine surgery typically requires a longer time in the operating room than most other procedures performed with single-lung ventilation.

Indications and Contraindications

Indications for the thoracoscopic approach for metastatic spine disease are as follows:

- Pathological fractures
- Spinal cord compression
- Anterior column support after posterior surgery

Contraindications for the thoracoscopic approach are most commonly related to patient comorbidities that make single-lung ventilation difficult, such as cardiopulmonary disease, chronic obstructive pulmonary disease, extensive lung metastasis, and prior thoracic surgeries that create lung adhesions. In addition, patients should have acceptable bone quality and normal coagulation studies.

Patient Education and Informed Consent

The patient should be advised of the potential complications associated with anesthesia and surgery and give consent for the surgery. Risks associated with anterior thoracic spine surgery include the following:

- Spinal cord injury and nerve and sympathetic trunk injury
- Injury to the greater vessels
- Thoracic duct injury
- Injuries to the spleen, liver, and kidney
- Diaphragmatic hernia

Patients who agree to a thoracoscopic approach should also be advised of the possibility and give consent for possible conversion to a mini-open or open thoracotomy.

Operative Technique

The operative steps are illustrated in Fig. 8.1, which illustrates a patient treated with the thoracoscopic insertion of an expandable cage [2].

Patient Positioning

The approach side is selected based on the location of the great vessels (i.e., aorta and inferior vena cava) in relation to the spine. Most commonly, a left-sided approach is used to access the thoracolumbar junction (T11–L2). For the upper and mid-thoracic spine (T3–T10), a right-sided approach is preferred.

In the operating room, the patient is placed in the lateral decubitus position on a radiolucent table. We use three to four supports (sacrum, pubic bone, scapula, sternum) and a U-shaped cushion between the patient's legs to place the patient perpendicular to the floor. An axillary roll is placed, and the suspended arm is supported using a Krause armrest. Intraoperative fluoroscopy is used to verify patient's spine position, alignment, and level of pathology.

Thoracoscopic Access and Exposure

We use fluoroscopy to design our spine access. The skin surface is marked with the anatomical structures of interest—the vertebral bodies, the associated disc spaces, the anterior and posterior

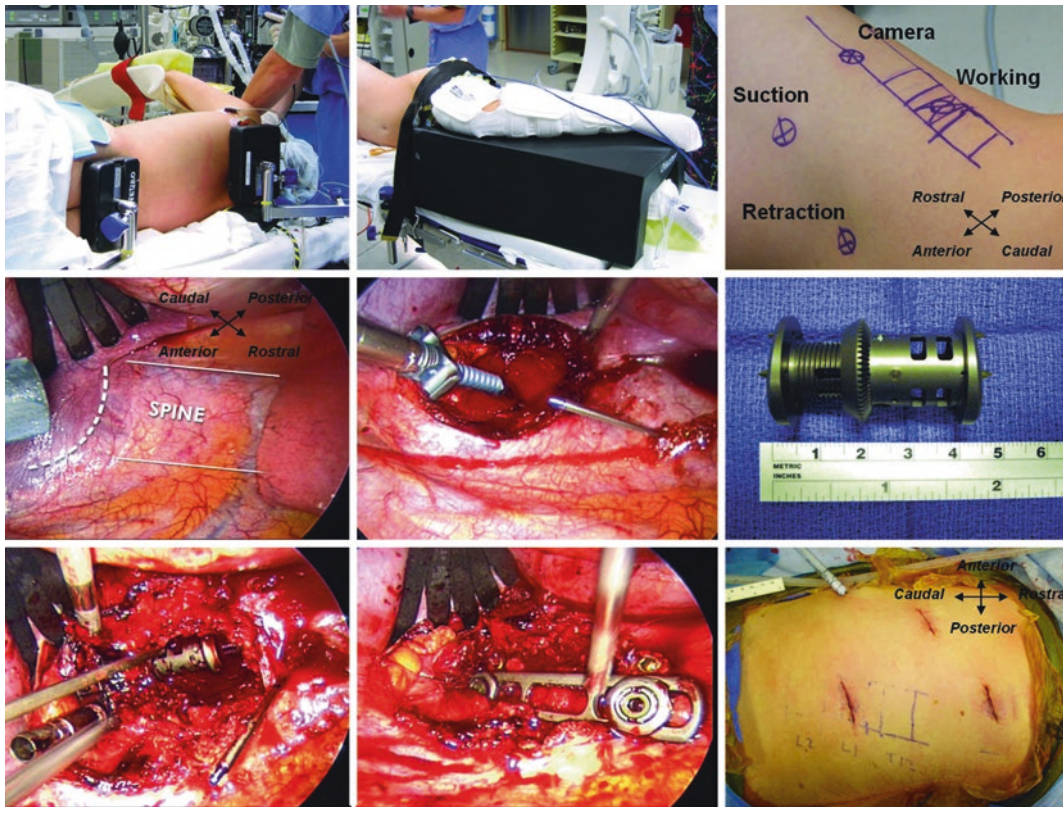

Fig. 8.1 Thoracoscopic decompression and fixation. (Reproduced from Ragel et al. [2], by permission of Oxford University Press)

spinal lines—as well as the surgical access sites (i.e., ports). For most thoracoscopic cases, a four-portal technique is sufficient for a corpectomy. In large patients, sometimes a fifth port is needed so that the targeted vertebra(e) can be reached more easily.

1. A *working portal* is placed directly over the vertebral body that is to be resected. It is typically larger than the other ports. This allows for access via two adjacent intercostal rib spaces and also allows for easier placement of an expandable cage through one incision.
2. An *endoscope portal* is placed two to three vertebral bodies above the working portal in line with the spine. For cases at the thoracolumbar junction, the endoscope is placed in a cranial direction relative to the working port. For upper thoracic cases, it is placed caudal to the working port.
3. The *retraction portal* is placed anterior to the working portal for safe retraction of the diaphragm and the lung.
4. A *suction irrigation portal* is placed between the retraction and the endoscope portals.

This configuration allows for all instruments to converge on the target vertebrae and avoids "fencing" of the endoscopic tools. After the portal locations are identified, we initiate single-lung ventilation to give the lung time to deflate (Fig. 8.2). The chest wall is then disinfected, and the area is sterilely draped to allow for possible conversion to an open technique if necessary.

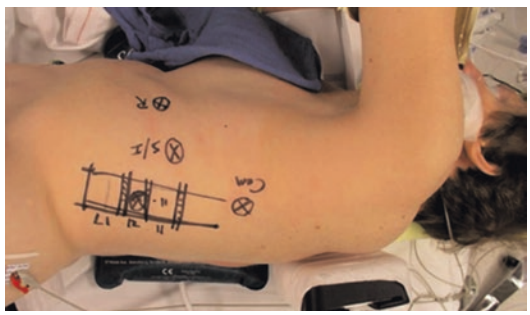

Fig. 8.2 Thoracoscopic patient positioning and working ports. (Reproduced with permission from Amini et al. [3])

To avoid iatrogenic injury to the underlying solid organs, the first port is placed at the location furthest away from the diaphragm. This incision is similar to the technique used to place a chest tube. After the skin incision, the rib is exposed. The thoracic cavity is entered carefully under direct vision with a blunt Kelly clamp. Once the pleural space is opened, manual palpation is performed to locate any pleural adhesions. Once it is determined that the pleural space is clear, the initial trocar is inserted and the 30-degree endoscope is introduced into the thoracic cavity. After a 360-degree survey has been performed, the remaining three trocar sites are placed under endoscopic visualization. Thus, no trocar is inserted "blindly." At this point, the key anatomical structures including the spine, diaphragm, aorta, and azygos vein, are identified. For orientation, we rotate the image on the monitor so that the spine is parallel to the lower edge of the video monitor.

Thoracolumbar Junction Access

The diaphragm typically inserts to the spine at the level of T12–L1 disc space. To gain access to the retroperitoneal portion of the upper lumbar spine, the diaphragm needs to be opened. This can be done endoscopically at the thinnest portion of the diaphragm with a harmonic scalpel. This allows for access to the L1–L2 levels. Once the diaphragm has been split, the retroperitoneal fat and peritoneum are bluntly dissected away from the fascia of the psoas muscle to expose the vertebral bodies.

Vertebral Body Exposure

Exposing the thoracic vertebral bodies and discs requires elevation of a pleural flap using the harmonic scalpel and identification of the segmental vessels, which lie transversely across the mid-portion of the vertebral body deep to the parietal pleura. These vessels are then ligated and divided, thus completing the exposure to the lateral vertebral body and discs.

Placement of Screws and Instrumentation

We use the MACS TL endoscopic anterolateral plate for anterior fixation in all cases. The system includes two clamps and four screws (two anterior stabilization screws and two posterior polyaxial vertebral body screws). One clamp and two screws are used at each vertebral body adjacent to the diseased vertebra. Using a short K-wire placed under fluoroscopic guidance as a guide, a cannulated awl is used to decorticate each screw entry point. The polyaxial screw clamp is assembled and inserted, and the K-wire is removed after the screw has engaged the cortical surface. To avoid the course of the segmental arteries along the midline of the vertebral bodies, the posterior polyaxial screw is inserted 10 mm anterior to the spinal canal in the upper or lower third of the vertebral body (for the screw above the diseased level and the screw below the diseased level, respectively). After the polyaxial posterior screws have been placed above and below the diseased body, the clamps are oriented perpendicular to the anterior aspect of the vertebral body with careful consideration to the surrounding great vessels.

Corpectomy and Spinal Canal Decompression

Discectomy and corpectomy are performed in a similar manner to an open procedure. The discs are incised using an elongated endoscopic scalpel and removed with rongeurs. The vertebral body in question is removed using a median corpectomy with straight and curved osteotomes. The ipsilateral rib head is traced to the ipsilateral pedicle and neural foramen located at its base so that the pedicle can be removed using a high-speed drill and endoscopic Kerrison punches. Free bone fragments and epidural tumor are maneuvered to the central corpectomy cavity and removed to avoid excessive manipulation of the spinal cord. These procedures allow for direct decompression and visualization of the anterior spinal cord.

Interbody Reconstruction and Endoscopic Stabilization

The thoracolumbar junction is reconstructed with an expandable cage inserted under direct fluoroscopic visualization after complete corpectomy. Once placed, the cage is expanded and distracted, and allograft is packed around the cage itself. The anterolateral plate is placed over the posterior polyaxial screws, the posterior screws are tightened, and the anterior stabilization screws are placed at each level. The screw plate construct is then locked and torqued. A final anterior/posterior and lateral fluoroscopic image is obtained prior to closure to verify hardware positioning.

Placement of Chest Tube and Closure

The diaphragm is sutured closed, and the operative field and the entire thoracic cavity are irrigated. A 24-Fr chest tube is placed through the inferolateral port or the lateral suction port under direct or thoracoscopic visualization, and the lung is reinflated. Before closure, the operative field is viewed to ensure proper lung reinflation and no bleeding from the surface. Port sites are closed in layers and the chest tube is secured in place.

Results

In a recent publication, we reviewed our experience in 12 patients who underwent a thoracoscopic spine surgery for metastatic disease [4]. The mean age of patients was 59 years, and the mean estimated blood loss was 613 ml. The mean duration of the operation was 234 minutes. The median length of stay in the hospital was 7.5 days (range 5–21 days). All 12 patients had improvement in their postoperative pain scores in comparison with their preoperative pain scores, and no patients suffered from worsening neurological function after surgery. Of the 7 patients who presented with neurological dysfunction, 6 (86%) had an improvement in their Frankel grade after surgery. No patients experienced delayed hard-

ware failure requiring reoperation over a mean follow-up of 10 months (range 1–45 months).

Conclusion

Over the past two decades, endoscopic surgery has become a viable option for patients with metastatic spine disease. The retroperitoneal part of the thoracolumbar junction can be accessed with a small diaphragmatic incision. The results and outcomes of the thoracoscopic approach compare well with standard open surgery.

Acknowledgments This chapter is based on previous works by the authors Kalra RR, Schmidt MH, and Beisse R. Thoracoscopic decompression and fixation for thoracic and thoracolumbar junction lesions. In: Kim DH, Fessler RG, Regan JJ, editors. *Endoscopic Spine Surgery and Instrumentation*. New York: Thieme; 2016 and Ravindra VM, Brock A, Awad AW, Kalra R, Schmidt MH. The role of the mini-open thoracoscopic-assisted approach in the management of metastatic spine disease at the thoracolumbar junction. *Neurosurg Focus* 2016;41(2):E16.

References

1. Zuckerman SL, Laufer I, Sahgal A, Yamada YJ, Schmidt MH, Chou D, et al. When less is more: the indications for MIS techniques and separation surgery in metastatic spine disease. Spine (Phila Pa 1976). 2016;41(Suppl 20):S246–S53.
2. Ragel BT, Amini A, Schmidt MH. Thoracoscopic vertebral body replacement with an expandable cage after ventral spinal canal decompression. Neurosurgery. 2007;61(5 Suppl 2):317–22; discussion 22–3
3. Amini A, Beisse R and Schmidt MH. Thoracoscopic spine surgery for decompression and stabilization of the anterolateral thoracolumbar spine. Neurosurg Focus. 2005;19:E4.
4. Ravindra VM, Brock A, Awad AW, Kalra R, Schmidt MH. The role of the mini-open thoracoscopic-assisted approach in the management of metastatic spine disease at the thoracolumbar junction. Neurosurg Focus. 2016;41(2):E16.