Endoscopy is a well known diagnostic procedure for more than a hundred years. Following the first laparoscopic cholecystectomy in 1985, gradually, it has become a desirable treatment modality both for patients and surgeons due to its superiority like less pain, shorter stay and quick recovery with better cosmesis.

While laparoscopic surgery spreading worldwide its education is still showing changes between countries and even between different hospitals of the same institutions. Industry helps for education of residents and practicing surgeons, but independent nonprofit organizations should be the first address to standardize the education. Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) is a well established organization, and they have formulated fundamentals of laparoscopic surgery (FLS) courses to certify the attendants. The program is designed for basic laparoscopic skills and it is not specific to any surgical specialties or procedures [1, 2].

The purpose of this chapter is to emphasize necessary topics of laparoscopic and thoracoscopic vertebral surgery in order to create awareness for the neurosurgeons interested in minimal invasive surgery.

In this particular surgery, surgical team should include neurosurgeons and general and/or thoracic surgeons who are capable to prepare cavity through the vertebrae, and if required to repair major vascular injuries or other organ injuries.

Before beginning to laparoscopic or thoracoscopic surgery, it should be recognized that there are two main differences between open and laparoscopic/thoracoscopic surgeries in the practice. Firstly, it is cognitive part and second is hand skills. Cognitive part is different than conventional surgery; while, the first and last points are the same in both, the driven ways are somewhat different. Prior to clinical practice, the below topics are to be learned very well in advance:

- Operation room setup,
- Anesthesia,
- Physiology of pneumoperitoneum,
- For thoracoscopy physiology of single lung ventilation,
- Instruments,
- Energy sources,
- Patient selection,
- Preoperative preparation,
- Patient positioning
- Theoretical part of trocar placement and removing,
- Entry injuries and mechanisms of peroperative injuries,
- Postoperative care of patient,
- Limitations of surgeon for instruments and techniques familiarity.

Secondly, hand skill part is also different; while eye-hand coordination is provided by the same route physiologically with open surgery there is no real hand contact with target tissue and surgeon cannot see the target tissue directly as in the open surgery, instead there are optical instruments providing a different, but enhanced image. The challenge is 2 dimensional pictures on TV monitors which should be reconstructed as 3 dimensional views in the brain of the surgeon. This reconstruction requires first, perfect anatomy knowledge, then orientation which necessitates repeated practices namely, reading, training, watching, assistance and performing.
To expand hand skills, it is easy first to derive the benefits of training boxes. Initially, for the expansion of the basic skills, small, simple, non-expensive, camera built-in boxes with real laparoscopic instruments are effective and economic. Hand skills like bimanual transferring beads, cutting exercises, suturing, intra- and extracorporeal knotting can be built up easily. Although, there are some varieties, these systems are mainly based on McGill Inanimate System for Training and Evaluation of Laparoscopic Skills program, originally developed by Dr. Fried and colleagues at McGill University in Montreal, QC (3-5). After these basic technical skills, to become familiar to related milieu and to exercise some maneuvers, simulator training boxes are available. These are simple simulators of different anatomical parts of human body (Figure 1-4). Related anatomical structures and their surrounding tissues, organs should be handled with care as in real surgery, and dissection, retraction, exposition and all that exercises should be carried out. Angled scope orientation can be vital, and exploration with different angled scopes, like 0, 30 and 45, should be practiced in these simulators.

Figure 1: Hand skills should be developed with simulators.

Figure 2: These pictures shows one of the FLS training box to exercise for increasing hands coordination (1, 2).

Figure 3: Orientation should be exercised with a real laparoscopic instrument on simulators.

After practicing with the training boxes, animal lab is mandatory for trocar placement and living tissue experiences which improve tactile skills, and taught to deal with bleedings, organ injuries or wound healing issue, namely, peroperative and post-
operative challenges. Handling various instruments, like dissectors, graspers, energy sources, etc with both hands also helps improving tactile skills.

After expanding of both cognitive knowledge and technical skills, surgeon is being welcomed in operating theatre. Holding camera to assist an experienced surgeon is the best learning chance for a young surgeon.

References


Figure 4: Animal lab is one of the main parts of minimal invasive surgical education.
1. Introduction

Minimally invasive surgery is a current goal for surgical intervention. Technical improvement in endoscopy has a major role in the practice of minimally invasive surgery. Thoracoscopic spine surgery is a relatively modern technique that allows for reaching and treating pathology of the spine with the same accuracy and completeness as is possible by open surgery. Effectiveness of endoscopic thoracic spine surgery is an other important factor that considers the place of endoscope in thoracic spine surgery.

The advantages of endoscopic techniques include small incisions; reduction in forced lung vital capacity, decreased pain and early mobilization and in particle can be applied to a wide variety of thoracic spine disorders. Thoracoscopy are currently used in many spine conditions, it is beneficial to correct thoracic spine deformities in the treatment of scoliotic deformity, central and calcified of disc herniation, corpectomy in spine body fracture tumor, infections as tuberculosis and diagnostic biopsy. Clinical studies revealed that thoracoscopic spine surgery has significant useful compared with open thoracal surgery for the treatment of thoracic spine disease. Although thoracoscopic spine surgery is a minimal invasive technology, and have many benefits for patient, but it may have indemnifiable results. Thus, before performing thoracoscopic spine surgery techniques, one must be familiar with using of endoscopic techniques and endoscopic surgical anatomy of thorax, patient situation and position, and anesthetic requirement.

1.a. History:

Historical period of thoracoscopy can be divided to three period beginning, interval and late periods. The first clinical report of thoracoscopic surgery was described in 1910 after Jacobaeus used a thoracoscope to diagnose and lyse the tuberculosis lung adhesion. Before this beginning in the 19th century, thoracoscopy was also used for diagnosing and evaluating of pleural disease. With the discovery of streptomycin in 1945 for tuberculosis treatment, there was a decreased in clinical application of thoracoscopy for such condition. This interval period had quietly passed until 1991. Lewis had defined again the use of thoracoscope for many pulmonary disease treatments.

The application of thoracoscope for spine disease was independently developed by two colleagues Mack-Regan and Rosenthal. They have popularized the use of thoracoscope for thoracic spine disease. The first article of the thoracoscopy for spinal disease was published by Mack and associates. The enthusiasm in using thoracoscopic technique for wide variety of thoracic spine disease has exploded, and numerous reports have studied and proved the effectiveness of this technique for treatment of thoracic spine diseases.

1.b. Surgical Anatomy:

The majority of thoracoscopic approach for thoracic spine disease is from the right side where there is a greater working spinal surface area lateral to the azygous vein than that to the aorta. Below T9, a left-sided approach is made possible that the aorta has moved away from the left posterolateral aspect of the spine to an anterior position as it passes through the diaphragm(s). Access to the thorax cavity is per-
formed appropriate to anatomic position of organs to avoid of morbidity. Major vessels as aorta artery, vena cava and vena azigous must clearly prevent. Our thoracoscopic experience showed that before choice the side of working, best evaluation of radiologic examinations to learn. Anatomic variation of vessels can help to approach with less mortality. The ligation of the segmental intercostals vessels at the waist of vertebral body is a controversial subject. Many authors oppose to perform ligation of the segmental vessels and preserve these vessels when doing discectomies alone and without instrumentation and to divide and retract the vessels to expose the vertebral body. Winter showed in 1197 patients that ligation of segmental vessels have no neurologic deficit. In our practice to ligation these vessels when doing discectomies alone or instrumentation demonstrated no neurologic deficits.

Thoracoscopic surgery can be performed to Th3 from Th10 easily. But the entire thoracolumbar junction can be restricted exposure with thoracoscope. Intimate knowledge of the anatomic landmarks is necessary in surgery. The diaphragm has muscle fiber, spleen in the left and liver in the right cause to extend diaphragm to thorax cavity and limit the thoracoscopic exposure. A good retraction of diaphragm to down shows perfectly Th11, even same part of Th12.

2. Indications:

Thoracoscopic surgical technique can be performed to thoracic spine via thoracotomy. There is no strictly defined indication for this technique. Thoracoscopic surgery has been reported to be successfully done in a variety of thoracic spine disease such as biopsy, discectomy, deformity surgery, tumor removal and reconstruction, trauma that caused spine body fracture such as burst or compression fracture that caused anterior spinal cord compression, infection dehiscence such as osteomyelitis and tuberculosis, congenital or acquired deformity correction and fusion and finally sympathectomy. The indications of thoracoscopic spine surgery were briefly summarized below;

- Sympathectomy: Raynaund’s disease, palma hyperhidrosis, reflex sympathetic dystrophy and other indication that is available for open surgical sympathectomy.
- Discectomy: Midline and calcified thoracic disc herniation.
- Resection of intrathoracic nerve sheath tumors: such as schwannomas, neurofibromas.
- Drainage of abscesses: tuberculosis, seconder infections
- Thoracic corpectomy and vertebral reconstruction with anterior screw-rod and interbody fixations:
  a) Acquired deformity: Thoracal spinal fractures, intervertebral or paravertebral tumors (metastasis, plasmositoma) that cause compressive cord spine fractures
  b) Congenital thoracic spine deformity: Rigid kyphosis, rigid scoliosis, neuromuscular spinal deformity.
- Diagnostic biopsy: paravertebral or vertebra location.

3. Contraindications:

Contraindications to thoracoscopic approach are resembled to general surgery and thorax surgery. The patient general situation, systematic disorders as cardiac or pulmonary disease increase morbidity of surgery. Briefly, the contraindications for thoracoscopic surgery are:

- Systemic disorders: cardiac disease as severe obstruction at coronary vessels
  - Pulmonary diseases chronic obstructive lung disease =COLD
  - Uncontrollable coagulopathy
- Traumatic reasons:
  - Hemothorax, emphysema
  - Prior trauma that may have cause pleura adhesions
- Surgical reasons:
  - Prior thoracotomy may have massive adhesion
  - Emphysema

3.a. Comparison of thoracoscopy with traditional approaches:

Thoracoscopic spine surgery has many advantage and disadvantage with compare of thoracotomy and disadvantage with compare of thoracotomy
and costotransversectomy approaches. Comparison of operative approaches to the thoracic spine was summarized in Table 1 (4). In fact the main aims of approaches are similar but the routes of approach are different. Therefore the degree of morbidity associated with thoracoscopy and thoracotomy such as pain syndromes, intercostals neurology, pulmonary dysfunction are not same. Although studies about thoracoscopic spine surgery are usually advocated from thoracoscopy with compare of thoracotomy, but open surgery has advantages such as better exposure, easy surgical manipulation, easy homeostasis when vessel damage that thoracoscopy lack. It is obvious that thoracoscopy reduces the morbidity and pain associated with the anterior transthoracic approach while preserving the broad, direct view and unobstructed surgical access to the entire ventral surface of the spine and spinal cord. The other benefits of thoracoscopy are minimal muscular incisions, no rib resection.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Thoracoscopy</th>
<th>Thoracotomy</th>
<th>Costotransversectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direction of approach</td>
<td>Anterolateral</td>
<td>Anterolateral</td>
<td>Postolateral</td>
</tr>
<tr>
<td>View of ventral surface of spinal cord</td>
<td>Full, direct</td>
<td>Full, direct</td>
<td>Oblique, indirect</td>
</tr>
<tr>
<td>Size of incisions</td>
<td>0.5-1 inch (x 3-4 inches)</td>
<td>6 to 15 inches</td>
<td>4 to 12 inches</td>
</tr>
<tr>
<td>Muscle transaction</td>
<td>Minimal</td>
<td>Extensive</td>
<td>Moderate or extensive</td>
</tr>
<tr>
<td>Postoperative chest tube</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Access to posterior spinal elements for decompression or fixation</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Access to vertebral bodies for screw-plate fixation</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Extend of rib resection or rib retraction</td>
<td>1 inch of rib head and proximal rib removed, no retraction</td>
<td>6 to 12 inches of rib removed, extensive retraction</td>
<td>3 to 7 inches of rib removed, moderate retraction</td>
</tr>
<tr>
<td>Incidence of postoperative intercostals neuralgia</td>
<td>Rare, usually transient</td>
<td>Common, often prolonged</td>
<td>Uncommon, often transient</td>
</tr>
</tbody>
</table>

Table 1: Comparison of operative approaches to the thoracic spine
4. Surgical Procedures:

4.a. Surgical Equipment:
The instruments which use in thoracoscopic surgery are the same instruments which are used in endoscopic thorax surgery, but the distance in thoracoscopic approach is longer than in classic procedures. Therefore equipments which are used in thoracotomy. Equipments are showed in (Figure 1).

4.b. Operating room set up:
A spacious operating room is advisable for thoracic surgery. The expensive equipments such as two monitors and flouroscopy and large number of personnel and surgeons are needed to large operation room. The anesthesiology team is positioned at the head of operating table. Flouroscopy equipment is covered with stril wrap and is positioned at the foot of operating table (patient) to verify the disease level before incision and to obtain lateral and anterior-posterior intraoperative images (Figure 2).

4.c. Patient positioning:
The procedure was performed under general anesthesia on a radiolucent operating table. Endotracheal intubation with a double-lumen tube was applied to all patients. All initial preparations such as arterial line, central nervous catheter, pneumatic compression stockings and urinary catheter were placed. All patients were also prepared for conventional thoracotomy that might be performed if complications occurred during thoracoscopic surgery. Then the patients were generally turned and placed in a right- or left-up lateral decubitis position with the side to be operated on facing up.

4.d. Surgical Technique:
Three to four portal trocars were used depending on localization of the target. The first 10 mm portal was placed directly over the target spine or disc segment posterolaterally between the posterior axillary and the midline. The second portal was on the cross point of the anterior axillary line and transverse line that passed first portal (Figure 3). This method permitted us compatible manipulation during the procedure and the use of 0 and 30 degree-angled optics during operation in all varieties of spine disorders. Nearly, in all thoracic spine disorder, basic considerations such as operating room setup and patient positioning, thoracoscopic imaging and instruments, portal insertion and wound closure and early postoperative management in all cases were similar. A 32-Fr chest tube was inserted before lung expansion and wound closure.

Figure 1:
The equipments which are used in thoracoscopic spine surgery is longer than in classic procedures.
5. Post operative care:

The chest tubes were placed at 20cm H₂O of suction. All patients were kept in the postoperative ward and monitored closely for heart rate, arterial pressure, respiratory rate, oxygen saturation and any respiratory complications. All patients were examined by plain chest X-ray for adequate lung inflation, and chest CT’s can obtained in patients to determine any lung complications. Different procedures were performed to treat various spine disorders by thoracoscopic spine surgery.

6. Complications and Avoidance:

Many potential complications of thoracoscopic spinal surgery have been reported. The rate of the most common complications encountered in thoracoscopic spine surgery is intercostal neuralgia (7.7%) and symptomatic atelectasis (6.4 %). Postoperative atelectasis and pneumonia can be decreased by temporarily reinflating the lung intraoperatively. Ventilating the lung 10 minutes for every 2 hours of surgical time is recommended⁴. Other thoracoscopic spine surgery complications are excessive (over 2lt) intraoperative blood loss (2.5-5.5 %), pneumonia (1-3%), wound infections (1-3%), chylothorax (1%). Cardiac arrhythmias are reported. These complications are prevented by avoiding monopolar cautery near the heart and pulmonary lacerations are avoided by minimizing or avoiding lung retraction⁴.

Hemidiaphragm and pericardial penetration, tension pneumothorax, long thoracic nerve injury, pulmonary embolism simultaneous bilateral pneumothoraces and pneumoretroperitoneum which subcutaneous emphysema are less reported thoracoscopic spine surgery.
7. Discussion:

Thoracoscopic spine surgery is a minimally invasive technique that is used for accessing and treating spine disorders. Due to the excellent results obtained, its continued use is encouraged in situations in which a conventional approach (11). Thoracoscopy can be used to access or treat a variety of spine disorders. The fact that thoracoscopic spine surgery is less invasive consequently makes it more beneficial than open thoracotomy or costoversectomy; this is currently widely known, and supported by the relevant literature.

Rosenthal and Dickman reported the results of 55 consecutive patients undergoing thoracoscopic microsurgical excision of herniated thoracic discs (3). They found that 60% of myelopathic patients and 79% of radiculopathic patients improved. They compared open surgery results to their patients treated by thoracoscopic surgery. They showed that thoracoscopic discectomy was associated with 50% less blood loss and an hour less operative time. Anand and Regan reported that thoracoscopic surgery for thoracic disc disease has an overall long-term satisfaction rate of 84% and a clinical success rate of 70% for refractory thoracic disc disease.

The other condition for which thoracoscopy is used in the thoracic spine is osteomyelitis; mostly tubercular spondylitis of tuberculosis patients. 3% to 10% have involvement of the skeletal system; vertebral tuberculosis constitutes 50% of all cases, of which 44% occurs in the dorsal spine (12). The use of thoracoscopy to obtain tissue confirmation for a faster and more reliable diagnosis has been reported (13). Thoracoscopic surgery obtains radical debridement, leading to direct visualization of the dural sac and kyphotic deformity correction with interbody cage and anterior screwing.

Huang et al. showed the reliability and effectiveness of thoracoscopy in the management of ten patients with dorsal tuberculous spondylitis (14). There was no recurrence of infection at the 24 month follow-up examination. But there was increased kyphotic deformity in two patients secondary to rib graft subsidence. Many authors believe that a rib graft cannot supply safe stabilization for the anterior part of vertebrae, because the superior and inferior rib bones are small. We prefer use of a crista iliac bone graft that could carry more load, with earlier stabilization of fusion.

The use of thoracoscopic spine surgery in management of traumatic and osteoporotic compressive fractures has been described in the literature. Dickman et al. compared outcomes of fracture management between open thoracotomy and thoracoscopic surgery groups (15). A significant reduction in narcotic use, ICU and hospital stay in the thoracoscopic group was reported. The main problem later on is pseudoarthrosis. There is a high incidence of pseudoarthrosis if an allograft is to be used (16). As we have described before, autogenous bone graft, particularly iliac crest graft, is the current standard treatment of choice to avoid pseudoarthrosis.

Thoracoscopic spine surgery in the management of primary and metastatic spinal tumors has been described as an alternative procedure to open thoracotomy. The use of thoracoscopic spine surgery for spine tumors with infiltration to important adjacent tissue is high-risk. These have to be exercised with caution. Huang et al. (17) reported that 5% of perioperative deaths were related to respiratory complications. The complication rate is in Anand and Regan (18) study with a 21% rate, McAfee et al. with a 20.5% and Huang et al. (17) with a 24.4% rate.

In our belief, although the term “video assisted thoracoscopic surgery” (VATS) is an explanation, it is no longer appropriately termed for endoscopic spine surgery. The word “thoracoscopic” alone describes the video-assisted technique and surgery region; therefore use of “video assisted” is unnecessary in endoscopic surgery. Thoracoscopic spine surgery includes all thoracic spine surgery by endoscope.

In conclusion, thoracoscopic spine surgery is applicable to all patients with various spine diseases. There is no significant difference in time of operation, blood loss, ICU stay or ward parameters between the different spine diseases. The pe-
operative morbidity associated with the thoracoscopic approach is lower than that associated with thoracotomy. Oswestry disability scores showed significant improvement in long term functional scores. The use of thoracoscopic spine surgery is adequate to replace video assisted thoracoscopic surgery (VATS).

8. Case illustrations:

Case 1: (Figure 4)
- 35 years old, female patient
- back pain
- normal neurologic examination
- tuberculosis osteomyelitis

Case 2: (Figure 5)
- 53 years old, male patient
- severe back pain
- neurologically intact
- thoracic disc herniation

Case 3: (Figure 6)
- 32 years old, female patient

Figure 4: a) Preoperative X-ray b) preoperative MRI c) postoperative x-ray

Figure 5: a and b) Preoperative MRI c) postoperative CT
Endoscopic Thorocal Procedures (VATS)

- traffic accident
- paraplegia
- traumatic fracture-dislocation

Case 4: (Figure 7)
- 39 years old, female patient
- back pain
- normal neurologic examination
- Under follow-up for breast ca, Radical mastectomy 1 year ago

Case 5: (Figure 8)
- 85 years old, male patient
- back pain
- neurologically intact
- under follow-up for Prostat ca

Figure 6: a) Preoperative CT and MRI b) postoperative CT

Figure 7: a) Preoperative MRI b) postoperative x-ray
9. References:


Figure 8: a and b) Preoperative MRI c) postoperative x-ray
1. Introduction:

Technical improvement in endoscopy has a major role in the practice of minimally invasive surgery which is a current goal of surgical intervention. For the patient, the benefits of endoscopic thoracic discectomy are that it is less invasive and it results in less surgical trauma, less pain, possibility less morbidity and less scaring (1).

According to results of computed tomographic (CT) scans, the incidence of thoracic disc herniation is approximately one patient per 1 million individuals (2) and according to result of magnetic resonance imaging (MRI) and post myelographic CT scanning has found an 11.1% to 14.5% prevalence of thoracic disc herniations (2-4). It is low incidence and present with a variety of nonspecific findings. They may be leads to a wrong or delayed diagnosis (4-7).

Endoscopic thoracic discectomy has the advantages of anterior approach in the patients with central ossified thoracic disc herniations. The traditional surgery for these patients is anterior approach with thoracotomy. Endoscopic thoracic discectomy has significantly reduced the chest wall morbidity related to the thoracotomy. Thoracoscopic spine surgery clearly provides minimally invasive and effective alternative top open thoracic surgery. Surgeon must be familiar with the surgical anatomy and the endoscopic techniques to ensure optimal surgical outcome. Hence, that causes limitation in practice of thoracoscopic discectomy. In the other hand, the excellent results of thoracoscopic discectomy encourage it is application to situations in which conventional thoracic approach is indicated.

2. History:

The application of thoracoscope for discectomy was independently developed by Mack-Regan (8) and Rosenthal (9). They have popularized the use of thoracoscope for thoracic discectomy. The first article of the thoracoscopy for spinal disease was published by Mack and associates (8). The enthusiasm is using thoracoscopic technique for central and hard thoracic disc herniation.

3. Anatomical Specialty in Thoracoscopic Approach:

There are many anatomical point should be care by surgeons to avoid complication peroperatively. The majority of thoracoscopic surgery for thoracic disc herniation is from the right side where there is a greater working spinal surface area lateral to the azygos vein than that to the aorta (10).

Thoracoscopic approach of left side is done possible blow Th9 where the aorta has moved away from the left postero-lateral of the spine to an anterior position s it passes through the diaphragm.

Anatomical orientation definitely plays a major role in thoracoscopic surgery. Columna vertebrae, aorta rib and pedicles are anatomic signs that lead surgeon. For location of disc level, the rib heads provide essential landmarks. The pedicles are dense oval cylinders of bone with a cancellous center. They connect the vertebral bodies with the remainder of the posterior arch (11).

Space between the ribs joins the transverse process and the vertebral body with the surface of pedicle produce costo-vertebral triangle. This space has
Thoracoscopic Discectomy

4. Operative Technique:

The procedure was performed under general anesthesia on a radiolucent operating table. Endotracheal intubation with a double-lumen tube was applied to all patients. All initial preparations such as arterial line, central nervous catheter, pneumatic compression stockings and urinary catheter were placed. All patients were also prepared for conventional thoracotomy that might be performed if complications occurred during thoracoscopic surgery. Then the patients were generally turned and placed in a right- or left-up lateral decubitis position with the side to be operated on facing up. Fluoroscopy (c-arm) was positioned to verify the disease level before incision and to obtain lateral and anterior-posterior intraoperative images as defined in chapter 4b.

Three to four portal trocars were used depending on localization of the target. The first 10 mm portal was placed directly over the target spine or disc segment posterolaterally between the posterior axillary and the midline as in chapter 4b. Second portal was on the cross point of the anterior axillary line and transverse line that passed first portal. This method permitted us compatible manipulation during the procedure and the use of 0 and 30 degree-angled optics during operation in all varieties of spine disorders. Spinal canal is visualized by removing the superior portion of the pedicle. Tracing the superior edge of the pedicle to the vertebral body and the disc space lead to explore of the disc herniation.

In all patients’, general considerations such as operating room setup and patient positioning, thoracoscopic imaging and instruments, portal insertion and wound closure and early postoperative management in all cases are similar. A 32-Fr chest tube is inserted before lung expansion and wound closure.

Preoperative and postoperative MRI and CT figures of a thoracal disc disease which is operated via thoracoscopic endoscopic approach is seen in figure 1a, b and c.

5. Thoracoscopic discectomy results:

Correct indication and choice of adequate patient thoracoscopic surgery have a major point to reach good surgery results.

Rosenthal and Dickman reported the results of 55 consecutive patients undergoing thoracoscopic discectomy (9). Among these patients 79% of radiculopathic patients recovered completely, whereas 60% of the myelopathic patients recovered neurologically. The perioperative morbidity associated with the thoracoscopic thoracic spine approach is less than the thoracotomy.

6. References:


![Figure 1: A calcified Th8-9 central disc herniation: a, b) Preoperative T2 weighted sagittal MRI c) postoperative axial CT scan is seen.](image)
1. Introduction:

Endoscopic surgical techniques are used in many disciplines after its first usage in gastroenterological interventions. It has come into market in spinal surgery especially following its use in pulmonary surgery. Thoracoscopic management of spine tumors are first performed by Raffenberg in 1981 and published in 1990. Meanwhile, it is practiced in many clinics all over the world, though not so widespread yet.

Recently, endoscopic procedures are successfully performed for the management of spine tumors. Endoscopic approaches should be chosen for appropriate cases if the surgeon has adequate experience. Endoscopic approaches are also performed to paraspinal pathologies.

2. Indications and Contrindications:

The general indications and contrindications of thoracoscopy and thoracal spine tumors are available for thoracoscopic spine tumor approaches and written in chapter 4b. Primer spine tumors can be managed easily with endoscopic approaches. They generally arise from the osseous and cartilage tissues. Especially, the osteoid osteoma and osteoblastoma and other osteoid based tumors and sarcomas can be excised with thoracoscopic approaches. Although it is rare, biopsy and/or total excision of thoracal cordomas and primer paraspinal soft tissue tumors can be achieved via endoscopy.

Except metastatic tumors such as prostate, lung, breast and renal carcinomas, the lymphomas and multiple myelomas can also be excised with endoscopic approach.

3. Surgical Procedures:

3.a. Surgical equipment:
The instruments of thoracoscopic spine surgery are similar with routine thoracoscopic surgery instruments and they also defined in chapter 4b.

3.b. Operating room set up:
The surgeon is positioned at the right or left side according to the pathology and the assistant is located opposite to the surgeon. While the anesthesia team is located at the head of the table, the nurse is at the right side of the surgeon. The monitors of endoscopy and scopy must be positioned at the opposite side of the surgeon while the scopy is located at the foot of the operating table (figure 1).

3.c. Patient Positioning:
The patient is positioned in left or right lateral decubitis position depending on the localisation of the pathology after the induction of general anesthesia (Figure 2). The patient is covered after staining and marking of the thoracar entrance localizations.

3.d. Surgical Technique:
The preoperative surgical planning is important especially to arrange the working channel of the endoscope.

The general tendency is to perform the working channel on the projection of the pathology in front of the midaxillary line with a pathological view. The bone grafts and/or cages are performed via these windows. However, the working windows just on the pathology are needed with a right angle to the pathology, if the instrumentation is necessary.
The number and localization of the incisions depend on the level of the pathology on the vertebral column. One of the incisions for trochar entrance is for the light source and one for lung ecartation. A third incision is placed on the mid axillary line or slightly behind it to access directly to the vertebral corpus (figure 3a). Anatomically, there is difficulty for the lesions of the Th1–4 th vertebrae and those caudal to the Th11th vertebra.

If instrumentation is planned, the incision must be right at the mid axillary line. But where access to the spinal cord is mandatory, the incision must be anterior to this line. Thus, the spinal canal will be under control entirely. Trochars are manipulated through small incisions on the thoracal wall. After entering to the thoracal cavity, with the help of fluoroscopy, the vertebral level is defined and the pleura is incised.

As a general rule, the pleura which is on the pathology is incised after arriving to the thorax cavity. After incising the parietal pleura, the capsule at the head of costo-vertebral joint is incised and costovertebral articulation is excised so that access to the vertebral body from side is possible. Because the costovertebral articulation adheres to the intervertebral disc, the upper edge of the caudal vertebral body and the lower edge of the cranial vertebral body (figure 3b). The segmentary artery and vein at the pathologic vertebral level are identified and cauterized. The distal end of this artery is cut at the point of enterance to the foramen, and the proximal end is cut close to its exit from the aorta. Cauterising the distal end in the foramen deeply may disturb the arterial anastomosis feeding the spinal cord. The excision of costovertebral joint increase the working area and provide to control the lower and upper disc levels.

The tumor tissue can be excised totally, because of its soft characteristics. The cartilage endplates of the upper and lower vertebrae must be protected to avoid from the spreading to the closer structures especially in metastatic tumors (Figure 3c,d). The posterior wall of the vertebrae comprise the anterior all
of the spinal canal with strong structure called as posterior longitudinal ligament. It will better to change the drilling tip with dimond one when we come closer to posterior wall of vertebrae. While working in this area, using the multidirection kerrison rongeurs with long shaft may decrease the operation time. If the tumor has a sclerotic structure, high speed drills can be used. After the tumor resection, hemostasis of the operation area is performed. The bone grafts insertion can be performed to the tumor resected area (Figure 3e). The appropriate spinal implants can be constructed to maintain the stability of the thoracal vertebrae after the resection of the tumor (Figure 3f). A 32-Fr chest tube is inserted to avoid from atelectasia and hemothorax before closing the pleura, subcutaneous and cutaneous tissues.

4. Postoperative Care:

The patients stay at the postoperative care unit in first day. The major possible problem is the continuing atelectasis after operation. For these reason, to control the blood gase levels and urine output of the patient is important after operation.

Because of the speciality of surgery, prophylactic antibiotics should be used. The costae are not broken in thoracoscopic endoscopy, so the postoperative pain is less than classical approches. The patient do not need more analgesics and can be mobilized in the first day after postoperative care unit. Dailey PA chest graphies may provide the early diagnosis of atelectasis and possible infection.
5. Complications and Avoidance:

Generally, the partial or total vertebrectomy with tumoral resection may cause to major bleeding. For this reason, the chest tube must be located after operation.

Complications of this procedure are: atelectasis, gross hemorrhage, pulmonary injury, spinal cord injury, tension pneumothorax. This technique needs a step learning curve. Tactile feedback for the surgeon is impossible during this surgery. A pulmonary surgeon is generally needed to attend to the session. A perfect three dimension visualization during discectomy is impossible.

Multiple stab incisions for trocar incisions, perhaps one more for ecartation of incompletely collapsed lung, and a retractor for the diaphragm are all considered to be the unfavorable points for this surgery. The preparations for conventional thoracotomy must be completed before thoracoscopic procedures for major complication occurrence.

6. Case Illustrations:

Case 1:

A 40 year-old woman, admitted to our department with complaints of back pain and dyspnea for one month. The history of the patient revealed a right breast carcinoma one year ago and she was accompanying a 7 year old dialysis.

The radiological images of the patient showed mass at the corpus of Th5 vertebra (Figure 4a,4b). The metastatic mass of the thoracic vertebra body was resected via thoracoscopic approach. After the resection of the tumor, thoracic implant was located to the resection of the mass to avoid from the spinal instability (Figure 4c,d).

7. References:


Figure 3c: The photo is showing the opening of the paravertebral structures.
Figure 3d: The photo is showing the tumor resection located at the vertebra body.

Figure 3e: The photo is showing the insertion of bone graft.
Figure 3f: The photo is showing the insertion of the thoracal implant.
1. Introduction:

After the adventure endoscopic surgery and usage for the management of lung based pathologies, it is carried to the endoscopic approaches of thoracic spine pathologies. The major advantages of endoscopic surgery is the elimination of thoracotomy. For this reason, the patient does not cause to the thoracotomy pain which is one of the main source of the pain after surgery. The surgical approach is maintained with two trocars on the thorax.

Generally, there are two kinds of traumatic processes. The first is the new fractures at the vertebrae or dislocation. The second is the osteoporotic fractures.

Because of the easy separation of mosaic like bone pieces at the vertebrae fractures of new trauma, they can be excised easily with endoscopic approach. The spinal canal can be decompressed easily with this method. The alignment of vertebrae at the dislocation can be maintained via posterior approach instrumentation. If the fracture line accross the disc level, the bone graft is inserted after discectomy.

The first choice is vertebroplasty or kyphoplasty at the osteoporotic fractures. However, surgical approach can be necessary for the total collapsed or stucked upper and lower endplate cases.

3. Surgical Procedures:

3.a. Surgical equipment:

The instruments of thoracoscopic trauma surgery are similar with routine thoracoscopic surgery instruments and defined in chapter 4b.

3.b. Operating room set up:

The surgeon is positioned at the ventral side of the patient while the assistant is located opposite to the surgeon. While the anesthesia team is located at the head of the table, the nurse is at the right side of the surgeon. The monitors of endoscopy and scopy must be positioned at the opposite side of the surgeon. If the monitor is single it can be located at the foot of the operating table behind the scopy. Also, the operating room set up is similar with chapter 4b (Figure 1).

3.c. Patient Positioning:

The patient is positioned in right lateral decubitis position to maintain the aorta at the upper side. The 15° posterior angulation of the thoracic body will increase the visualisation of spinal canal. The patient is covered after staining and marking of the thoracar entrance localizations.
3.d. Surgical Technique:

The localization of working channels are arranged according to the surgical plan. One of the port is located anterior of the midaxillary line just opposite to the fractured vertebra and the light and aspiration ports are located to the upper and lower of the first port. If the surgical plan includes the insertion of spinal implant, it will be better to maintain an additional port just above the fractured vertebra. The endoscopic approach is proper between the Th4 and Th11 vertebrae.

After the fixation of vertebra, the upper and lower disc levels are marked. The pleura is elevated at the lateral sides of the vertebral column to control anterior part of the fractured vertebrae. The arterial and venous structures lying above the fractured vertebrae are coagulated proximally or near the vertebral foramina and removed from the operational area. Discectomy is performed to the upper and lower disc levels of the fractured vertebrae. After discectomy, the fractured and mosaic shaped bone pieces are excised via pulling to the abdominal space. It will be better to avoid compressing the spinal canal while excising the fractured bone pieces. We must be careful while working on the posterior longitudinal ligament (PLL). The big sized bone pieces can be excised via high speed drilling. If the PLL is teared, duramater and also the spinal cord can be damaged. The excessive bleeding can occur via epidural venous plexus or arterial structures which are feeding the vertebrae. The bipolar coagulator, bone wax and surgicel can be used to control the bleeding. The cartilage endplates of the upper and lower vertebrae corpus can be excised with courteous osteotomes and/or high speed drill.

The suitable bone graft or cage can be inserted to the excised area of the fractured vertebra. If it is decided to insert a cage, the autolog bone grafts can be used which are excised during vertebrectomy. One of the advantage of the cage is to avoid the surgeon for an extra autolog bone graft excision. The sizes of the cage and position and adaptation with the vertebrectomy area is controlled under scopy. The minimal bleeding of the bone structures can be controlled via placing spongostan behind and above the cage or bone graft.

The vertebra corpus disappears and the upper and lower disc levels kiss for the cases of advanced osteoporotic vertebra fractures. After the excision of degenerated and sequestre disc pieces between two vertebrae, the osseous endplates of upper and lower vertebrae is planed and bone graft is inserted into the vertebrectomy area. Because of the hard shape, cage insertion is not suitable for advanced osteoporotic cases. The upper and lower vertebrae corpuses can be damaged.

Dislocations of the thoracal vertebrae occured after trauma is straightened via posterior instrumentation before thoracoscopic approach. Because of the dislocation point is at the disc level, traumatic disc tissue is excised and osseous endplates are smoothed. Using long shafted multidirection kerrison ron-
geurs may decrease the operation time. Additionally, 0° or 30° optics can be chosen for thoracoscopic trauma surgery. A 32-Fr chest tube is inserted to avoid from atelectasis and hemothorax before closing the pleura, subcutaneous and cutaneous tissues of working channels.

4. Postoperative Care:

Postoperative care unit is suggested after surgery for one day. Daily routine chest graphy may alert the possible athelectasis problem after operation. Controlling the arterial gase levels and urine output of the patient is important after operation. Prophylactic antibiotics should be taken to avoid form a possible infection.

5. Complications and Avoidance:

Complications of this procedure are: gross hemorrhage, great vessels injury, pulmonary injury, athelectasis, spinal cord injury, tension pneumothorax. The multidicipliner approach can be necessi-
ate under this circumstances. The vena cava inferior damage is one of the biggest problem during the thoracoscopy procedure. A special operation instrument which is opening as goose foot is located between the thorax cavity and operatin area. Exces-
se bleeding may occur via vertebrectomy area or epidural space. The bleeding must be controlled in every stage of the surgical approach. The preparing of upper and lower vertebral surfaces before decompressing the spinal canal may avoid the surgeon from the excessive epidural bleeding. The suddenly graft insertion and spongostanes may contribute to control the bleeding.

6. Case Illustrations:

A 35 year-old female admitted to our emergency clinic with complaints of unable to walk and move her legs. Her history revealed that she had a traffic accident 5 days ago. Her physical examination revealed a decubitus ulcer at mid-low back. Neurological examination showed a complete paraplegia. The radiological studies (X-ray graphies, spinal MRI, chest CT) showed Th5-6 fracture dislocation and bilateral hemothorax (Figure 2a-d). Bilateral thorax tubes were put and hematoma drainage was achieved.

Posterior Th6 laminectomy was performed, duramater was opened and the spinal cord was transected. After the closure of duramater, bilateral Th3-4-5-7-8 pedicle screw fixation was performed.

**Figure 2:** Preoperative a) sagittal reconstruction and b,c) axial CT scans and d) T2 weighted MRI scan of the traumatic vertebra is seen.
Following posterior approach, thoracic endoscopic approach was performed to the Th6 vertebra via left thorax cavity and Th6 vertebra corpus was resected and bone graft was inserted to the Th6 corpectomy area (figure 3a,b) (figure 4a,b). The patient was transferred to the ICU after the operation and discharged at 2 weeks after the operation.

7. References:

Figure 3: Peroperative endoscopic figures, a) trocar approach, b) bone graft insertion after corpectomy.

Figure 4: Postoperative a) AP X-ray b) Sagittal reconstruction CT scan of the operated vertebra is seen.
1. Introduction:

In an attempt to improve the correction and minimize the rate of pseudoarthrosis anterior access to the spine is commonly used when surgically treating spinal deformities. The typical approach would be via thoracotomy to manipulate the lungs and the great vessels in order to access the spine. Thoracotomy however is associated with significant morbidity including; reduction of pulmonary functions (mostly temporary), chronic post thoracotomy pain syndrome, reduction and/or pain during shoulder function, and unsightly scars.

In an attempt to minimize these issues, thoracoscopic techniques have been developed. Although not many spine surgeons have adopted this approach, today, spinal releases, discectomies and even instrumentation and correction can be undertaken successfully.

Thoracoscopy can be performed with the patient in a lateral decubitus or prone position. Prone position thoracoscopy can enable a simultaneous classical posterior approach for the instrumentation and correction of scoliotic curves (1-3) (Figure 1a, b, c).

2. Indications:

Anterior releases are indicated for the release of rigid and severe scoliosis curves and to minimize the risk of pseudoarthrosis and crankshafting. The indications for a thoracoscopic release are somewhat narrowed to those with a curve less than 70-80 degrees, with less than 50% correction in bending films. Patient’s size is also a factor to consider; as in too small a patient, the portals may be so large that the cosmetic benefit may be lost, and the space within the chest does not allow access to the spine or manipulation of the tools. In general, it is best to perform this procedure to patients over 40 kg.

3. Contraindications:

The contraindications to a thoracoscopic approach include; previous open lung surgery, bullous emphysema, lung parenchymal disease, lung abscess or active infection, previous empyema or pleurodesis, lung capacity insufficient to tolerate single lung ventilation during surgery.

4. Informed Consent:

Many patients agree to undergo thoracoscopy because of its relatively rapid recovery and cosmetic superiority when compared to conventional thoracotomy. They must however be aware of the potential for conversion to an open thoracotomy due to excessive bleeding that can not be stopped, injury to major blood vessels or trachea or bronchi or other issues that can not be addressed via a thoracoscopic approach. The patient should understand risks and benefits involved in this procedure and give informed consent.

5. Surgical Technique:

For a simultaneous approach the patient is positioned prone onto a spinal frame. Double-lumen intubation is used for single lung inflation. It is important to note that in prone position the lung gen-
**Figure 1:** Patient positioning for the thoracoscopic operation:

a) Lateral decubitus position,

b) Prone position with a convex side approach,

c) Prone position with a concave side approach. Note that simultaneous posterior approach can be carried out in both of the prone thoracoscopic approaches.
eraly falls out of harms way and the surgeon – after gaining familiarity with the procedure- will no longer need single lung inflation and this will reduce complications related to single lung inflation. The tube must be secured to avoid any change in position while turning the patient from supine to prone. The back is prepared in a standard fashion. Attention to detail must be taken to ensure that the inferior limit of draping is at least at the anterior axillary line to enable thoracoscopic approach. The posterior spine exposure can be performed first or at the same time as the thoracoscopic exposure to the index levels (Figure 1d).

The thoracoscopic approach depends on the surgeon’s preference. One can choose to approach the spine from the concavity or convexity. Approaching from the convexity enables an easier discectomy but additional portals may be required to gain parallel access to the disc spaces. Approaching from the concavity also facilitates an internal thoracoplasty. A concave side approach enables excision of the tethering structures (posterolateral corner and costotransverse ligaments) under direct view, with fewer portals (Figure 1e). It also allows for parallel access to the entire disc space.

The first portal should be created opposite the apex of the curve at the midaxillary line. This is the only portal inserted blindly and should be done with caution similar to placing a chest tube. This portal is opened bluntly and the subsequent portals will be created after the 30 degree endoscope is inserted to facilitate direct vision of the other portal sites. The secondary portals are placed 2 intercostal spaces cranial and caudal to the first one. The portal pattern may be “L” or “V” shaped depending on surgeon preference and curve type and direction. A fourth portal can be used for suction if necessary. This portal is generally created 2 intercostal spaces proximal at the midaxillary line (Figure 1f).

6. Complications and Postoperative Care:

Thoracoscopy is a relatively safe procedure if adequate visualization is ensured throughout the operation. The most frequent complications are intercostal neuralgias, transient chest wall paresthesias, pleural effusion and postoperative mucus plugging. These issues are mostly temporary and tend to resolve in time.
Major complications of thoracoscopy include injury to the spinal cord, lungs (pneumothorax), major blood vessels and lymphatic structures. To minimize injury the surgeon should be patient and introduce and use the instruments only after adequate visualization. To gain experience with this technique, on a planned thoracotomy case, the surgeon can first introduce the thoracoscope, inspect the pleural cavity and increase familiarity with the endoscopic view of the anatomical structures and then proceed with classical thoracotomy. It is also important to note that prone position thoracoscopy helps the major mediastinal organs and lungs fall anterior and out of the danger zone. The prone position however may disorient the surgeon as the spine is superior on the horizontal view. All work and manipulation are done in an uphill fashion.

Bleeding of the minor vessels can frequently complicate the procedure and lengthen the operative time as it is not as easy as during an open approach to address these bleeding points. Segmental vessels can be clipped and cut and bleeding from the bone can be stopped using bone wax. Collagen based haemostatic agents can also be used.

During the thoracoscopic approach to T12-L1 the diaphragm retraction. If this proves difficult the surgeon should be prepared to convert to a mini thoracotomy at that level. Finally it is important to keep in mind that any inexperienced surgeon should not hesitate to convert the approach to a classical open one if any problems occur in any stage of the operation. In the prone position this can be achieved using an extended costotrasversectomy approach.

The postoperative course of prone position thoracoscopy and simultaneous posterior instrumentation is very similar to that of a posterior instrumentation alone. A thoracic tube is placed after thoracoscopy to evacuate any hematoma or post-operative pleural effusions. The tube should be removed after the drainage drops below 100cc in every 8 hour shift. This usually can be accomplished after the second postoperative day.
7. Outcomes and Conclusion:

There is limited literature about prone position thoracoscopy and simultaneous posterior instrumentation. Cheung et al (4) reported on 11 patients followed up for 5.6 years. They got 15% flexibility increase after anterior thoracoscopic release and all patients were fused without using any anterior bone grafts.

Sucato et al (5) compared prone and lateral position thoracoscopy in a total of 43 patients and found no significant differences regarding the operative time per disc, blood loss per disc, and total chest tube drainage. Anesthesia preparation time, the time to start the posterior procedure and complications related to single lung inflation were significantly lower in the prone group. Also prone group required less time on oxygen and were discharged earlier.

Niemeyer et al (6) reported on 20 scoliosis patients who underwent anterior thoracoscopy and posterior instrumentation with a follow up of 2 years. They did not observe any vascular or neurologic complications.

King et al (7) reported on 27 patients who underwent the same procedure without any complications.

Lieberman et al (8) reported on 15 patients who underwent prone position thoracoscopic release and simultaneous posterior instrumentation without any intraoperative or postoperative (early or late) complications (figure 2a, b).

Prone position thoracoscopy is another tool with certain benefits in deformity cases. It should however be noted that the steep learning curve of this procedure requires dedication, patience and a good supporting team to get these benefits.

8. References:

Simultaneous Thoracoscopic Release and Posterior Instrumentation in Adolescent Idiopathic Scoliosis


Figure 2a:
Preoperative AP and lateral X-rays of an adolescent idiopathic scoliosis patient.

Figure 2b:
Postoperative AP and lateral X-rays of the same patient following simultaneous prone position anterior thoracoscopic release and posterior instrumented correction of the deformity.
1. Introduction

Thoracic sympathectomy (TS) is a procedure designed to interrupt the adrenergic effect of the central nervous system on the upper extremity. The predominant effects of sympathectomy are reduction of vasomotor tone and lowering of peripheral vascular resistance. These main effects are the prominent indications for the management of various autonomic-mediated disorders of the upper extremity \(^{(1)}\). Dr. Alexander was the first to perform an operation on the upper sympathetic chain in 1889 \(^{(2)}\). This surgical treatment was first described in 1940s \(^{(3)}\). Goetz’s excellent collective review in 1948 provided a historical and physiologic perspective of sympathectomy in cardiovascular disorders \(^{(4)}\). Through the parallel evolution of two seemingly unrelated and independent surgical developments—endoscopic surgery and thoracic sympathectomy—thoracoscopic sympathectomy has become the procedure of choice for thoracic sympathectomy \(^{(5,6)}\). Although Jaboulay in 1899 first proposed that sympathectomy might be of value in promoting circulation in the extremities \(^{(7)}\), Kotzareff is credited with having performed the first cervical sympathectomy for hyperhidrosis in 1920 \(^{(8)}\). An anterior cervical approach to the thoracic sympathetic chain was described independently by Jonnesco \(^{(9)}\) and Bruining \(^{(10)}\). During the evolution of this procedure, many different surgical techniques were described in the literature. After the 1980s, the resection and/or cauterization of the sympathetic chain became popular, until Lin et al introduced a simple clipping technique \(^{(2)}\). The specific advantages and disadvantages of each of these surgical approaches have been thoroughly reviewed by Roos \(^{(11)}\). By the development of the anesthetic techniques and single-lung ventilation, this stimulus to expand the scope of diagnostic procedures and encourage the therapeutic application of thoracoscopic surgery. The advent of the thoracoscopic equipments the results of the procedure became much more better with lower morbidity and mortality for the selected upper extremity. Although there are many different techniques described in the literature, there is still a debate which is the best surgical option. But the most important subject is there is even no consensus in describing the sympathectomy. Krasna made a very clear explanatory description for these surgical approaches \(^{(3)}\):

- **Thoracoscopic**: done with any means of thoracoscopy, including video-and standard eyepiece-assisted procedures,
- **Video-assisted thoracic surgery (VATS)**: refers only to those procedures that use a video camera to help with visualization of the intrathoracic cavity,
- **Sympathectomy**: refers to procedures in which the sympathetic chain is resected, ablated, or divided,
- **Sympathicotomy**: refers to the division of the sympathetic chain without removal of any section thereof. Unless otherwise specified, this would exclude ablation techniques that are done without a directed division of the chain,
- **Ablation**: refers to procedure where the chain is destroyed using electrocautery or laser without directed division,
- **Endoscopic thoracic sympathectomy**: another common term used more often in the nonthoracic surgery literature for sympathectomy.
Thoracoscopic Sympathectomy

2. Indications

Thoracic sympathectomy is indicated for a variety of sympathetic disorders. Thoracoscopic sympathectomy has the same indication with the open procedures. In the literature the most common accepted indications for TS are as follows:

1- Sympathetic maintained causalgia or pain,
2- Palmar hyperhidrosis,
3- Non reconstructible arterial insufficiencies,
4- Raynaud syndrome,
5- Facial blushing,
6- Axillary sweating,
7- Cold sensitivity after cold injury,
8- Angina pectoris,
9- Long QT syndrome,
10- Reflex sympathetic dystrophy (Shoulder-hand syndrome, Sudeck's atrophy),
11- Splanchnicectomy for pancreatic pain.

The most common indication, and the indication in which the results are most satisfactory, is hyperhidrosis. The other indications listed above are very limited and the results are not as satisfactory as the hyperhidrosis. Probably the other most promising results get are as follows; axillary sweating, fascial blushing, cold sensitivity.

3. Contraindications

Although TS is a relatively safe operation applied as an outpatient procedure with very limited side effects and limitations, there are some contraindications.

The major contraindications are:
- Severe cardio-pulmonary insufficiency,
- Severe pleural diseases (empyema, pleuritis),
- Previous thoracotomy,
- Coagulopathy,
- Re-sympathectomies,
- Inability to maintain adequate arterial oxygen saturation with contralateral single-lung ventilation,
- Active infection.

There are also some relative contraindications as;
- Pleural adhesions and obliterations,
- Raynaud Syndrome with autoimmune disorders,
- Untreated hyperthyroidism,
- Very low heart rate,
- Infants and very small children,
- A very rare anatomical variant for right hemithorax; azygos lobe

4. Surgical Procedures

4.a. Surgical Equipment;

1- Video-endoscopic monitoring system,
   a) Optical telescope; 0° or 30° , 2mm, 5mm, 10 mm (Figure 1)
   b) Monitor,
   c) Carbon dioxide insufflation system,
   d) Video-recorder (Figure 2)

2- Trocar with different sizes according to the surgeon's preference and videoendoscopic equipment; 2mm, 3mm, 5mm, 10mm

3- Hook cautery
4- Grasper
5- Endoscopic scissors
6- Endoclips
7- Endoscopic aspirator
8- Suction catheters (Figure 3)
9- Silicone pad to place under the vertebral column (Figure 4).

10- All open surgical equipments should be kept by-side for any kind of emergencies.

4.b. Operating Room Set up

Operation room set up does not have so many differences from a conventional operation room. The most important equipment differing from conventional OR
is the video-endoscopic system. A very flexible operation table is very important for patient positioning (semi-fowler, trendelenburg, lateral decubitis etc). General anesthesia equipments with double lumen endotracheal intubation is essential (Figure 5).

4.c. Patient Positioning

According to the surgical technique; due to unilateral, bilateral operation, lateral decubitis, semi-fowler, fowler, supine, semi-prone positions could be chosen. If a bilateral operation is planned patient is in supine position with both arms abducted (Figure 4, 6). For an unilateral approach lateral decubitis position is better. For uni-bilateral anterior approach semi-fowler or fowler position could be the choice.

4.d. Surgical Technique

In general the operation is performed in supine or semifowler position a pad placed under the vertebral column under general anesthesia using a double lumen endotracheal tube. Although awake operation can be performed without any endotracheal intubation (13). Due to the procedure that will be applied to the sympathetic chain; transection, cauterization or clipping, tree port, double port or single port could be chosen respectively. The incision should be minimal due to the trocar size. We generally prefer double port with 5mm trocar in supine position with a silicone pad under the vertebral column. The first incision is made in the fourth sub-mammary intercostal space just below the pectoral muscle as an access route for camera, and a second incision is made at third midaxillary intercostal space to introduce surgical instruments. 5mm trocars are employed, during brief disconnection of the endotracheal tube to deflate the lung when the pleural...
Thoracoscopic Sympathectomy

The cavity is entered to avoid damaging the lung parenchyma and for adequate visualization of the surgical field (Figure 7a,b). Prior to the insertion of the camera 8-10 mmHg 2L/min carbon dioxide insufflation can be performed in collapsing the lung and assisting visibility. Also semi-fowler position allow gravity to help pull the upper lobes out of the field of dissection. As the most important and promising indication for TS is the hyperhidrosis Th2 level is the choice of the appropriate level. The selection of the level could be due to:

- For facial sweating or blushing, the Th2 level is isolated by dividing over or resecting between the Th2 and Th3 ribs. Some authors just make one cut over the middle or top of the Th2 rib without attempting to isolate the nevre further below. For patients with hand sweating, the Th2 and Th3 levels are isolated, Th3 and Th4 isolated for axillary sweating. In some reports Th4 level is accepted important for satisfactory results for axillary sweating.

- For specific fascial blushing high Th2 division taking care avoiding injury to stellate ganglion. Lower third of the stellate ganglion is also safe for Horner syndrome.

- For RSD, Raynaud Syndrome, causalgia Th2 to Th3 levels are satisfactory.

- For chronic pancreatic pain referred for splanchnicectomy Th4 to Th10 should be divided.

In order to perform a successful sympathectomy the defining the location of the sympathetic chain is essential. The pathway of the sympathetic trunk was classified into three types (Table 1)

The most common pathway is the medial type (14). The position of the sympathetic ganglion is another factor affecting surgical results; the location of the sympathetic ganglion was generally known as to be located in the middle portion of the intercostal space but near the upper border of the third rib (Figure 8).

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<th>Table 1: The pathway of the sympathetic trunk</th>
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Careful division of the nerve over the ribs can be achieved by using a shears cautery or a hook cautery. In this case care should be taken to avoid damage to the underlying periosteum because this can cause severe discomfort and sunburn-like pain in the postoperative period. Cauterize/divide the pleura for 5 cm laterally; in this way, if an aberrant nerve bundle of Kuntz is identified, it too is severed (Figure 9). The sympathetic chain is dissected free from surrounding tissue and the rami communicants were divided. Care is taken to avoid injury to the adjacent intercostal veins. The Kuntz nerve and accessory fibers are ablated with electrocautery whenever observed. Cautery should be avoided in the area proximal from the Th2 to preclude any hazard to the first thoracic ganglion and endoscopic scissors should be used. Separate the transected ends of the sympathetic chain as far as possible to prevent regrowth of the nerve. For the success of the procedure and prevention of side effects the anatomical variations and landmarks should be kept in mind. The most important alternate neural pathway is the Kuntz nerve which is located in the first intercostal space.

There are generally three types of alternate neural pathways (Table 2) (15).

The arrangement of the superior intercostal veins has surgical relevance because injury to these veins may cause troublesome bleeding that compromises dissection of the sympathetic chain. The superior intercostal vein is a large branch draining into the azygos vein in the region of the Th2. The prevertebral fascia overlying the longus colli muscle, which lies medial to the neck of the second rib, is an under-appreciated structure that may mimic the sympathetic chain. This is particularly so in asthenic patients.

After obtaining hemostasis, the lung is expanded. Gentle suction is applied to the trocar to evacuate intrathoracic air. And the incision is sutured. The same procedure is applied to the contralateral side. For awake TS the only difference is patients is under intercostal blockade and slight sedation. Generally we applied clip to T2 ganglia and applied suction while asked patient to take a deep breath. There is no need for chest tubes except the complicated cases.
5. Postoperative care

The patient is extubated in the operating room (except awake operations). A postoperative chest x-ray is obtained in the recovery room and the respiratory status is monitored closely. If patient suffers pain analgesia should be given in order to enhance the patient’s respiratory effort. The patient is transferred to a hospital room when appropriate. Typically around the globe this procedure is done as an outpatient operation with patients going home on the same day.

6. Complications and Avoidance

The potential complications of thoracoscopic sympathectomy include adverse occurrences that may result from any thoracoscopic procedure and complications specific to sympathectomy. Some general complications include:

- Pain
- Arrhythmia, severe bradycardia
- Hypotension
- Hypercarbia
- Hemorrhage
- Pneumothorax
- Persistent pulmonary parenchymal air leak
- Horner’s syndrome
- Subcutaneous emphysema
- Severe compensatory sweating
- Paresthesias
- Infection

The most common complication is the compensatory sweating. Most of the authors addresses the injury of a long segment of sympathetic chain. The other complications are very uncommon. But the most disabling complication is Horner’s syndrome. This complication is very uncommon (0.5%). To avoid this complication resection should be limited to the upper Th2 but the lower 1/3 of the stellat ganglion could be safely removed. Avoidence of usage of electrocautery at this level is essential.

The other complications could be avoided by knowing the anatomical landmarks and careful surgical dissection.

7. References


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<th>Table 2: Types of alternate neural pathways</th>
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