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 (1). Effectiveness of endoscopic thoracic spine surgery is another 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 (2). Thoracoscopic surgery 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 (3,4,5). 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 (6). Before this beginning in the 19th century, thoracoscopy was also used for diagnosing and evaluating of pleural disease (7). With the discovery of streptomycin in 1945 for tuberculosis treatment, there was a decreased in clinical application of thoracoscopy for such condition (8). 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 (9) and Rosenthal (3). 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 (5). The enthusiasm in using thoracoscopy 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 azigious 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. 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 neurologia, 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 thoracotomy 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>
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Table 1: Comparison of operative approaches to the thoracic spine
4. Surgical Procedures:

4.a. Surgical Equipment:
The instruments which are used 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 are the same as those used in thoracoscopic surgery. 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 steril 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%). Post-operative 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 recommended (²). 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 retraction (²).

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 Thoracic 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