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THE USE OF VIDEO ASSISTED THORACOSCOPIC SURGERY IN SPINAL DEFORMITY CORRECTION

VİDEO YARDIMLI TORAKOSKOPİK CERRAHİNİN SPİNAL DEFORMİTE DÜZELTİLMESİNDE KULLANIMI

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ABSTRACT:

Video-assisted thoracoscopic surgery has become an alternative treatment option for various spinal disorders in recent years. A thoracoscopic approach minimizes chest wall morbidity that is more commonly seen in traditional thoracotomy. Existing indications for video-assisted thoracoscopic surgery are the same as those of any traditional open anterior spinal surgery. Since, posterior surgery has advanced significantly over the past 20 years with the routine use of thoracic pedicle screws, posterior releases and apical rotation maneuvers, video-assisted thoracoscopic surgery has lost its popularity and is therefore rarely used today. The purpose of this article is to review video-assisted thoracoscopic surgery options in spinal deformity correction.

Keywords: Spinal deformity, video assisted thoracoscopic surgery

Level of evidence: Review article, Level V.

ÖZET:

Geçtiğimiz yıllarda video yardımlı torakoskopik cerrahi birçok spinal problem için geçerli bir seçenek haline gelmiştir. Torakoskopik yaklaşım, geleneksel torakotomide oluşan göğüs duvarı hasarını en aza indirir. Video yardımlı torakoskopik cerrahi endikasyonları geleneksel açık anterior spinal cerrahi endikasyonları ile aynıdır. Son 20 yılda posterior cerrahi, torasik pedikül vidalarının, posterior gevşetmelerin ve apikal rotasyon manevralarının rutin kullanımı ile belirgin olarak gelişmiştir. Bu nedenle video yardımlı torakoskopik cerrahi popülaritesini kaybetmiş ve bugün nadiren uygulanmaktadır. Bu makale spinal deformitelerin düzeltilmesinde video yardımlı torakoskopik cerrahi seçeneklerini derlemek amacıyla yazılmıştır.

Anahtar Kelimeler: Spinal Deformite, Video yardımlı torakoskopik cerrahi

Kanıt Düzeyi: Derleme, Düzey V.

INTRODUCTION:

The first report of thoracoscopic surgery was in 1910, after Jacobaeus used thoracoscopy to release tuberculosis lung adhesions. Although video-assisted thoracoscopic surgery (VATS) has been widely used in thoracic surgery since the early 1980's, it became popular in spine surgery in the 2000's. In literature, there are several reports about the advantages of VATS over traditional open thoracotomy in the treatment of spinal conditions. These reports show that patients had less postoperative pain and decreased narcotic requirements. Shoulder girdle function improved faster than open surgery due to less dissection of the latissimus dorsi, serratus anterior and intercostal muscles[1,6,16,26-29,34,38]. Patients also had shorter intensive care unit and hospital stay, decreased postoperative pain, improved patient satisfaction, superior cosmesis and better pulmonary function recovery[21,34,35].

VATS was first used for thoracoscopic anterior release (TAR), combined with posterior spinal fusion and instrumentation (PSFI) for treatment of severe curves and young patients who had a risk of crankshaft phenomenon[27,29,38]. As VATS technology advanced and surgical experiences grew, the indications for VATS expanded. Today, the indications of VATS in spine surgery include: treatment of thoracic disc diseases, tumor excision, fracture treatment, osteomyelitis, and draining intervertebral disc space abscess, thoracic vertebral inter-body fusion, and thoracoscopic anterior spinal fusion and instrumentation (TASFI) for spinal deformity correction[2,8,9,15,17,21,23,24,31,33].

VATS may be most beneficial in scoliosis surgery. In scoliosis, there is a need to access multiple vertebrae and intervertebral discs, from the upper to the lower thoracic spine. However, in thoracic disc disease and spinal infection, the pathology is limited to a local area and a mini-open thoracotomy can be used instead. In scoliosis surgery, multiple portals in the lateral chest wall provide unrestricted access to the thoracic vertebrae and disc spaces from T4 to L1 level[21].

The appropriate candidate for the TASFI procedure is an AIS patient with a right side thoracic (Lenke type 1) curve less than 80 degrees with a thoracic kyphosis less than 40 degrees. Although VATS is generally recommended for patients between 30 and 70 kilograms weight, Early et al. reported successful outcomes in children under 30 kilograms. However, they emphasized that very small patients (under 20 kg) should remain a relative contraindication to TASFI, especially during a surgeon's learning curve[6].

The primary disadvantage of TASFI is that it is technically demanding, has a steep learning curve, and requires special training and experience. The use of this technique has declined significantly because of increased surgical times, the technical difficulty, the delay in returning to preoperative athletic activities and issues related to safely placing anterior screws with the close proximity of the aorta on the contralateral spine[1,28,32,33]. Because of these factors, this procedure is rarely utilized today. Because of the proven efficacy and familiarity, PSFI has become the mainstay of spinal deformity surgery.

TECHNICAL ASPECTS:

A fiber optic camera and a light source is used in VATS for visualization and magnification through small multiple portals. The goal is to address the pathology with minimal injury to adjacent tissues. This approach offers direct lighting and 15 times magnification of the area. By changing the position of the thoracoscope, scope angle and camera route, VATS permit a clear visualization of the thoracic spine from T1 to T12 (21). Before performing a VATS, the surgeon should be aware of the surgical anatomy, anesthetic necessities, patient positioning and the endoscopic techniques to warrant an ideal surgical outcome. The majority of the VATS approach for spinal pathology is from the right side where there is a greater working spinal surface area lateral to the azygos vein compared to the aorta. A left-sided approach below the T9 is more possible because the aorta has moved away from the left posterolateral aspect of the spine to an anterior position[21].

Spinal levels may be determined during thoracoscopic surgery by locating the superior intercostal vein emptying into the superior azygos vein at the T3-4 interspace and by identifying the diaphragmatic insertion at the vertebrae in the caudal aspect. The T12 vertebra and the T12-L1 disc space may be found by using the anatomic landmarks of the diaphragm. Eventually, disc levels may be identified by taking an intra-operative radiograph to localize an intervertebral disc marked by a Steinman pin.

ANESTHESIA AND POSITIONING CONSIDERATIONS:

Routine testing of preoperative pulmonary function is advocated to select the appropriate approach for a patient with a thoracic scoliosis. The patients with scoliosis may have significant preoperative pulmonary morbidity besides the postsurgical decline in pulmonary function. It is important to determine the impact of the surgical approach on pulmonary function in order to choose the appropriate approach for the patient[7].

TAR and TASFI have been performed traditionally in lateral decubitus position with single-lung ventilation. The lateral position with single-lung ventilation requires repositioning and re-intubation for the posterior surgery. This increases the operative time and the morbidity of the procedure. Single-lung ventilation can lead to significant complications secondary to high air-way pressures and ventilation-perfusion mismatches that cause the "down lung syndrome"[32,34,35].

As a solution to some of the difficulties of the lateral position, some authors have described performing a TAR in the prone position[14,20,35]. Traditionally, in the lateral position a double-lumen endotracheal tube is used to deflate the ipsilateral lung. Prone positioning eliminates this need and double lung ventilation is used with decreased tidal volumes. Gravity helps in the retraction of the lung and eliminates the postoperative pulmonary issues seen with single lung ventilation[34]. Since, a TAR procedure can be performed with double lung ventilation in the prone position, the detrimental effects on pulmonary functions will be less than those seen in the single-lung ventilation[14,20,35].

PRONE POSITION THORACOSCOPIC ANTERIOR RELEASE (TAR) TECHNIQUE:

"The patient is positioned in the prone position. A regular single lumen endotracheal tube is generally used to achieve double-lung ventilation. After prone positioning of the patient, the anesthesiologist lowers the tidal volumes from the usual levels (8-10cc/kg) by approximately 30% to 50% while increasing the respiratory rate as tolerated by the patient. This provides for some lung deflation and easier access to the spine. The thoracoscopic portals are placed in a linear fashion usually in the posterior axillary line. The initial portal was placed so that it was approximately at the apex of the curve and a 30 degree 10-mm diameter thoracoscope is then placed through the existing portal. When initially placing the thoracoscope, the lens is directed posteriorly to find the space between the lung and the posterior chest wall. The thoracoscope is then directed over the top of the lung to visualize the spine, and the ribs are counted from proximal to distal to identify the levels to be released/ fused based on the preoperative plan. The remaining portals are placed under direct visualization using the thoracoscope. Typically, four portals are created and held the camera, a suction tube, a lung retractor, and a working instrument. Following placement of all portals, the pleura is incised in the midvertebral body level leaving the segmental vessels intact. The pleura is then bluntly dissected anteriorly to expose the entire anterior longitudinal ligament (ALL) with exposure of the annulus on the contralateral side and dissected posteriorly to identify the rib heads. The annulus and ALL are incised with a #15 scalpel blade, and the annulus and nucleus are disrupted with endoscopic disc shavers manually rotated within the disc space. Currettes and rongeurs are then used to remove the disc and endplate material and autologous bone or allograft are placed. The parietal pleura is closed with a running 2-0 absorbable suture, using the Endostitch device. Two running sutures are placed, one from distal to proximal and one proximal to distal, and tied in the center. Following pleural closure, the chest is cleared of debris and irrigated with normal saline. A chest tube is placed through the distal portal skin incision tunneled to the adjacent pleural entrance and secured to the skin with a suture" (Figure 1)[35].

Figure 1

Figure-1. A very severe and stiff double major curve with a marked coronal imbalance and apical rotation in a 14 year old girl. TAR, intraoperative halo-femoral traction and PSFI is used to achieve a balanced spine.

THORACOSCOPIC ANTERIOR SPINAL FUSION AND INSTRUMENTATION (TASFI) TECHNIQUE:

In order to perform TASFI, the lung on the convexity of the curve must be deflated. This is accomplished with a double-lumen endotracheal tube. Patients are positioned in the lateral decubitus position on a radiolucent operating table with the convexity of the curve up. The first port (12 mm) is placed at the apex of the curve in the anterior-to-midaxillary line and the thoracoscope is then placed through this portal. The thoracoscope consists of a camera and a scope that is angled at 30 or 45 degrees. The posterolateral portals are created under direct visualization. For the placement of the most cephalad portal the skin mark made under fluoroscopic visulation is used to place a guide pin, which is assessed using the camera in the anterolateral portal. The remaining posterolateral portals are then placed with careful attention to the distances between portals and their positions in the anteroposterior direction. Positioning is assessed with the thoracoscope in the anterior portal to ensure that the portals are made directly over the vertebral bodies. After incising the pleura in the midvertebral body, the segmental vessels is coagulated. The pleura is bluntly dissected posteriorly of the rib heads and anteriorly around the front of the spine to allow access to the anterior longitudinal ligament and contralateral annulus. Sharp incisons of the disk are made with a scalpel blade or a harmonic scalpel. Disk shavers, rongeurs, and curettes are used to excise the disk as completely as possible. Autologous iliac crest or allograft are used for grafting immediately upon completion of the discectomy at each level. Bone funnels are used to place the grafts. Before screws are placed, the patient's position is re-checked to ensure it is straight and lateral. The thoracoscope is placed in the anterior portal initially to direct the guide wire with respect to the superoinferior starting point and orientation. The thoracoscope is then moved to a posterolateral portal to check the anteroposterior starting point and its direction. Screws are placed beginning at the apex of the curve, with the starting point of the screw just anterior to the rib head. The screws are directed slightly anteriorly to avoid the spinal canal and to be in the midaxial plane of the rotated apical vertebral bodies. A single skin incision is used to place the screws 2 or 3 intercostal spaces to ensure optimal instrument alignment for screw placement. After all of the screws have been placed and checked fluoroscopically, the rod is measured, cut and inserted through the distal or proximal posterolateral portal and grasped within the chest with a rod grabber so that it could be seated into the screws in one step. The rod initially should be seated distally to help control the length of rod that protrudes distal to the screw and prevent it from pushing against the diaphragm. After compression and cantilever maneuvers are performed and the rod is captured in the proximal screw heads, compression is applied and screws are serially tightened. After coronal and sagittal correction and screw position are confirmed using fluoroscopy, the pleural incision is closed and the hemi-thorax is irrigated. A single chest tube is placed through one of the inferior portals and all incisions are closed in layers.

DISCUSSION:

Surgical treatment of scoliosis has changed rapidly in the last 20 years and still continues to improve. PSFI with pedicle screws, hooks and sublaminar wires was an improvement to the Harrington instrumentation because it developed correction in the coronal and sagittal planes. It allowed for an earlier return to daily activities, with overall improvement in spinal deformity correction. Posterior surgery has advanced with the routine use of thoracic pedicle screws, posterior releases and apical rotation maneuvers which has resulted in improved correction of the three-dimensional deformity. PSFI is performed routinely in most spine centers and offers stable fusion levels, good sagittal control and beneficial effects on pulmonary function, allowance to ambulate without postoperative bracing and low pseudoarthrosis rates[19,30,39].

Conversely, anterior spinal instrumentation and fusion is still a valid option for patients with thoracic curves. Deciding the surgical approach (posterior vs. anterior route) is based on the curve type, amount of correction desired, the number of motion levels to be fused, and the surgeon's experience[3,4,18]. Anterior instrumentation for thoracic adolescent idiopathic scoliosis (AIS) reached its peak in popularity in the late 1990's and early 2000's while offering comparable coronal plane correction with improved restoration of thoracic kyphosis and saving distal motion segments[3]. The anterior approach offers a mechanical advantage since the corrective force is applied at the greatest distance from the center of the curve and screws placed in the vertebral body have a 30% greater moment arm for applying corrective forces than posterior hooks[3,11,22]. This procedure traditionally requires a thoracotomy, which has an approach-related morbidity to pulmonary functions[13]. Additionally, the anterior procedure provides less rigid bony fixation, greater incidence of loss of fixation, implant-related failure and nonunion compared to PSFI[3,4,18].

With the advances in VATS, TASFI became popular in spine surgery in the 2000's. This technique minimizes numerous disadvantages of the open anterior thoracic approach. It provides improved cosmesis due to smaller incisions and less surgical scars, improved pulmonary function, and less postoperative pain associated with limited chest wall disruption. One of the disadvantages of VATS is the steep learning curve. The learning curve of VATS has been reported in several studies to have an influence on operating time[34]. The drawbacks of VATS are the technical difficulties including clear visualization, disc space access, doubts about the completeness of disc excision and the long surgical times[21].

Since this procedure is technically demanding, the incidence of complications can be high, especially in the surgeon's initial surgeries due to his lack of experience. Complications include blood vessel injury, lymphatic injury with resultant chylothorax, guide-pin migration into the opposite side of the chest with resultant pneumothorax[32].

An anterior release of the thoracic spine in combination with PSFI has traditionally been recommended for large (>70 degrees Cobb measurements) and stiff (less than 50 % flexibility index) curves, those that have thoracic hyper-kyphosis, or thoracic lordosis, and for skeletally immature patients who are at risk for the crankshaft phenomenon. Today, a posterior three-column fixation with pedicle screws is the gold standard in spinal deformity correction[19,30,39]. The use of pedicle screws provide a greater coronal and axial plane correction. Hence, the threshold to perform an anterior release is higher and only the most severe curves require an anterior release. Furthermore, there is early evidence that three-column fixation of the thoracic spine prevents the crankshaft phenomenon and may preclude the need of anterior fusion in young patients[3,4,18,19,30,32,35,39]. TAR for spinal deformity correction has several proposed advantages over the more traditional open thoracotomy while achieving similar results with respect to completion of discectomy and release of the spine[10,25]. This technique has traditionally been performed with the patient in the lateral position and requires single lung ventilation which results in significant physiologic stresses to the patient. These stresses include creating high airway pressures and barotrauma to the ventilated lung as well as air leakage or bronchial rupture or pneumothorax[36]. This can be exacerbated by the weight of the mediastinum on the lung/bronchial tree and ventilation-perfusion mismatches can occur because the upper lung is being perfused but not ventilated, which can lead to difficulty in maintaining adequate oxygenation[5,12,37]. The lateral decubitus position with single-lung ventilation requires the patient to be repositioned for posterior surgery, most often with re-intubation with a single lumen endotracheal tube after removal of the double lumen endotracheal tube, re-prepping with a sterile scrub, and sterile draping[34].

As a solution to the potential problems of the lateral decubitus position, some authors have recommended using the prone position when performing a TAR[14,20,35]. King et al.[14] reported 27 patients who were placed in the prone position using a standard single lumen endotracheal lumen, gaining entrance with a Veress needle and insufflation with a 4 mm Hg CO2. Leiberman et al.[20] reported 15 adult patients who had a prone anterior release and fusion using a double lumen endotracheal tube to obtain single-lung ventilation. Sucato and Elerson[34] introduced the concept of performing TAR in the prone position while ventilating both lungs and demonstrated significantly less pulmonary complications with this technique (0% vs 14.8%). Sucato's technique is utilized with a single lumen endotracheal tube which permits double-lung ventilation without the use of CO2 insufflation. The tidal volumes are decreased by approximately 30% to 50%, which is well tolerated by the patient and allows the lungs to fall away from the spine due to gravity. This provides for excellent visualization of the spine and faster operative time. In another study, Sucato et al.[35] also showed that there is no detrimental effect on pulmonary function when a prone TAR using double lung ventilation is added to a PSFI.

In conclusion, VATS in spinal deformity correction has several advantages over traditional open thoracotomy including less postoperative pain, faster improvement in shoulder girdle function, shorter intensive care unit and overall hospital stay, decreased postoperative pain, improved patient satisfaction, superior cosmesis, and better pulmonary function recovery. VATS provides a safe and effective alternative approach to spine surgery. Since, posterior surgery has advanced significantly over the past 20 years with the routine use of thoracic pedicle screws, posterior releases and apical rotation maneuvers, VATS has lost its popularity and is therefore rarely used today.

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