The Role of Video-Assisted Thoracoscopy in Scoliosis Treatment

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ABSTRACT
Video-assisted thoracoscopic surgery (VATS) has gained in popularity in the treatment of scoliosis in the last years. It is a minimally invasive surgery that prevents blood loss and results in minimal damage to the thoracic wall, better cosmetic appearance and shorter hospitalization time compared to conventional thoracotomy. Technical difficulty, a steep learning curve, longer operation times and applicability in a limited patient group with a certain type of curve are the disadvantages of this procedure. The role, indication, surgical technique and clinical results of the procedure were reviewed. Despite the small number of reports on VATS, the results are promising. VATS seems to be as effective as conventional thoracotomy in performing discectomy and anterior release. However, accepting VATS as an alternative to posterior instrumented fusion in adolescent idiopathic scoliosis has not been clarified and randomized clinical trials are still lacking.

KEY WORDS: Minimal invasive surgery, Scoliosis, Thoracoscopy, Vats

INTRODUCTION
Treatment of scoliosis aims to correct the threeplanar deformity to obtain a well-balanced spine by fusing as few levels as possible and reserving more spinal motion units over the pelvis (1,15). The surgical procedure becomes more aggressive and complex with increasing deformity. Although current classification systems like King’s and Lenke’s guide the surgeon in treatment strategy, each curve pattern must be considered individually before the surgery (9,22).

The decision whether to choose anterior or posterior surgical approaches has been a controversial issue. The posterior approach is outweighs the anterior approach in recent articles due to the ability to control three spinal columns with modern pedicle screws. This advantage of pedicle screws does not extinguish the need of anterior release or bone resections and the anterior approach is still being applied in a great number of cases (12).

The video-thoracoscopy assisted surgical technique (VATS) and related devices were developed to decrease the morbidity related to anterior surgical procedures. In this article, the indications and details of surgical techniques are reviewed and the clinical results discussed under the guidance of reported literature data.

Indication and Patient Selection:
The minimal invasive surgical technique of VATS allows access to the anterior spine in various spinal pathologies. The indications for VATS are similar to open thoracoscopic surgeries. Traditional indications of the anterior approach include a large curve magnitude (>75°); rigid deformity (Cobb angles >50° on side bending radiograph); thoracic lordosis (<10°); thoracic hyperkyphosis (>50°); and skeletal immaturity (Risser 0 and/or open triradiate cartilage). (25) Proponents of this
procedure emphasize that anterior thoracic spine surgery can be performed with the same accuracy and integrity as is possible by the conventional open approach in anterior spinal pathologies (8,18).

The reported criteria by different authors to select appropriate patients for undergoing the VATS procedure are also similar to open anterior surgery. Isolated thoracoscopic instrumentation of the thoracic spine requires a limited curve pattern in which selection of such fusion levels between T4 and L1 would be appropriate.

These are largely Lenke Type 1 curves with structural main thoracic curves and nonstructural proximal thoracic and lumbar curves. Despite the technical difficulties, anterior thoracoscopic instrumentation is also a preferred technique in AIS except for the indications cited above. Wong et al. (26) compared the early results of thoracoscopic instrumented fusion with the conventional posterior instrumented fusion in adolescent patients with AIS who were undergoing selective thoracic fusion. They found that the efficacy of thoracoscopic surgery was similar to standard posterior procedures. According to the findings of a more recent study, patients with single thoracic curve of <70° with a normal or hypokyphotic thoracic spine might have equivalent radiographic results, considering the superiority of thoracic pedicle screws in major curve correction (14).

The advantages of VATS such as less blood loss, shorter hospitalization and ICU stay and better cosmetic appearance may make it preferable to posterior surgeries in selected cases. VATS is superior to thoracotomy when lung functions are considered (17,19). Halm et al. highlighted another point regarding lung functions in the postoperative period in their comparative study between anterior and posterior techniques in scoliosis surgery. The data on posterior segmental transpedicular correction and fusion also prove a lordosating effect with negative effect on lung function (5).

VATS is not a suitable surgical procedure for patients with severe pulmonary disease or infection, those who had previous anterior surgery, patients who cannot tolerate single lung ventilation, and patients with double thoracic curves.

**Surgical Technique:**

VATS surgery is generally performed in the lateral decubitus position and rarely in the prone position. Using a double-lumen endotracheal tube is recommended to allow for single-lung ventilation. The spine can be approached from the side of the convexity. Somatosensory evoked potentials are monitored during the procedure. The thoracoscopic portals are placed in a linear fashion along either the anterior axillary line (lateral decubitus position) or the midaxillary line (prone position). The initial portal is placed at the apex of the deformity, and subsequent portals are placed two/three interspaces above and below. Three to five portals are required for scoliosis treatment. Initial visualization of the thoracic cavity is performed using a 10-mm endoscope; this can then be replaced with a working scope for the remainder of the procedure. Subsequently, the collapsed lung is retracted to expose the vertebrae and ribs. Segmental vessels are ligated at each surgical level to enhance the exposure and to minimize the bleeding. The parietal pleura, annulus fibrosus and anterior longitudinal ligament are divided with scalpel or electrocautery and discectomies are performed with endoscopic pituitary rongeurs. A guide pin is then placed into the vertebra under the guidance of the C-arm X-Ray device and thoracoscope. Cannulated screws are placed into the vertebrae. A rod and with an appropriate length is next introduced through working tunnels, the screws are tightly fixed and compression applied on each screw in a caudal-cephalad sequence. Grafting of the intervertebral spaces can be performed if needed. The pleurae are not sutured closed. Finally, a chest tube is placed, and the portals are closed. A Stagnara wake-up test is performed at the end of each procedure (13,14,24).

**DISCUSSION**

The VATS technique is a minimally invasive technique and has therefore gained in popularity for scoliosis surgery since the 1990s with numerous advantages to the patient and the physician. The need of surgical experience and the steep learning curve limits its application and widespread use so the data on VATS has gradually increased in recent publications (23). Lonner noted a significant difference in operating time and percent curve correction after 28 cases (11). The complication rates remained stable as the surgeon’s experience increased. They concluded that the learning curve associated with thoracoscopic spinal instrumentation appeared to be acceptable.

Two types of studies on VATS can be identified; VATS as an initial procedure in rigid type curves or in young children or thoracoscopic instrumentation and correction of scoliosis using the VATS technique as an essential
operation. The majority of studies using thoracoscopy in scoliosis have performed anterior release and discectomy.

The published clinical results have shown that VATS can be easily performed instead of a standard thoracotomy. Despite its potential advantage regarding efficacy, some major concerns remained and it was examined clinically and biomechanically. The key to a successful anterior fusion is a total discectomy and complete endplate removal. Newton et al. realized biomechanically equivalent release of disc spaces when comparing open and thoracoscopic methods in animal models (16,19).

It has been reported that the lack of 3-dimensional visualization with the thoracoscopic technique could make a 360° discectomy more difficult and dangerous than conventional thoracotomy. Treatment of AIS via anterior instrumentation has been shown to reduce the number of motion segments fused versus posterior instrumentation, and selective thoracic fusions improved spontaneous lumbar curve correction (1,3,8). Subsequently, anterior thoracoscopic instrumentation was performed in adolescent idiopathic scoliosis to benefit from the advantages of anterior instrumentation and to avoid chest wall trauma.

Weinzapfel et al. found that endoscopic thoracoscopic spinal deformity correction, fusion, and instrumentation was a safe and feasible surgical method in the management of progressive scoliosis of adolescents (25). This method was comparable to open procedures in terms of curve correction with significantly shorter hospitalization and rehabilitation due to less surgical discomfort.

The extent of the instrumentation whether conventional thoracotomy or VATS is chosen found comparable favorably with posterior procedures. However, certain parameters like the balance of the patient, cosmesis, status of the unfused lumbar curve, and the number of levels saved with anterior surgery were not investigated adequately. The difficulties associated with performing a long instrumentation has been acknowledged by Newton et al., who found that close to 10% of their thoracoscopic instrumented patients had been fused at least 1 level too short (18).

There is a paucity of reports comparing anterior thoracoscopic instrumentation in AIS with standard posterior instrumentation and conventional anterior instrumentation with thoracotomy. Wong et al. compared the clinical results of nineteen patients (group 1) who underwent posterior instrumented fusion with twelve patients (group 2) who had thoracoscopic anterior instrumented fusion (26). All patients were followed up for at least a few months. Their study showed a statistically significant difference in estimated blood loss (P=0.006), which was higher in the thoracoscopic group.

There was also a statistically significant difference in the operative time (252+/-35 min vs. 415+/-72 min), favoring the posterior group (P=0.0001). The number of days in the ICU was also found to be statistically significant (P=0.01) between the VATS and posterior group (2.6+/-1.3 days vs. 1.5+/-0.9 days). The difference between the two groups in terms of scoliosis improvement was not significant. In group 1, 50 degrees of preoperative scoliotic curve was reducted to 16 degrees and the correction coefficient was 67%. In group 2, 52 degrees of preoperative scoliotic curve was reducted to 20 degrees and the correction coefficient was 62%. Thoracic kyphosis (T2–T12) did not increase significantly with thoracoscopic versus posterior instrumentation. No other variable showed any statistical significance between the two groups. The VATS group, however, had 2 surgical complications, whereas the posterior group had none.

The study by Lonner et al. compared the surgical results of 28 patients with a mean age of 14.6 years who underwent VATS with a posterior group containing 23 patients with a mean age of 14.3 years. (12) The correction ratio was 54.5% for the thoracoscopic group and 55.3% for the posterior group. There was no significant difference between the two groups in terms of curve parameters of kyphosis (p = 0.84), coronal balance (p = 0.70), or tilt angle (p = 0.91). The mean number of levels fused was 5.8 in the thoracoscopic group, compared with 9.3 levels in the posterior group (p < 0.0001). No difference was found regarding the study variables between the 2 groups except for mean operative time that was higher in the VATS group (6.0 hours) than in the posterior group (3.3 hours) (P=0.0001). Vital capacity and peak flow between the thoracoscopic and posterior surgery groups were also examined and no significant difference was found (P=0.08 and P=0.25 respectively) between the groups (12). In a recently published study by the same authors, a matched-pair analysis of 34 consecutive patients (seventeen pairs) who underwent either video-assisted thoracoscopic surgery or posterior spinal fusion with thoracic pedicle
screws for the treatment of structural scoliosis was performed (14). The study included eight male and twenty-six female patients with an average age of 15.0 years. The authors found that, VATS was associated with significantly increased operative times and reduced blood loss.

There are also few comparative studies between anterior instrumentation performed with conventional open approach versus VATS. Grewal et al investigated the results of thoracoscopic instrumentation (41 patients) and open anterior instrumentation (114 patients) for spinal fusion in AIS prospectively (4). The operative time was shorter in the anterior instrumentation group (383 +/- 65 minutes) than thoracoscopic instrumentation (508 +/- 98 minutes) group. This difference was found to be statistically significant (P <0.01). There was less blood loss in the anterior instrumentation group (924 +/- 724 vs. 1218 +/- 747 mL; P 0.03). No statistically significant difference between the preoperative thoracic curves in the two groups (48.5 +/- 14° vs. 49.8 +/- 7°; P=0.6) was detected. The correction ratio of the thoracic curves was also reported to be similar (64% vs. 69%). Newton et al.’s study showed a statistically significant difference (P<0.001) in the operative time between thoracoscopic (343 +/- 47 minutes) and open anterior instrumentation (281 +/- 106 minutes) (17). The curve correction ratio did not vary between the two groups (48 degrees of preoperative scoliotic curve reduced to 21 degrees with a correction coefficient of 60% vs. 51 degrees of preoperative scoliotic curve reduced to 21 degrees with a correction coefficient of 59%). A significant difference was noticed between the groups for postoperative kyphosis (P=0.005). No other variables showed a statistically significant difference between the groups in the study.

Qui et al. compared thoracoscopic instrumentation (12 girls with a mean age of 14.9 years, mean Cobb angle of 52 degrees) with small incision thoracotomic anterior instrumentation (4 boys and 33 girls with a mean age of 14.1 years, mean Cobb angle of 56 degrees) (21). The thoracoscopy group had an average operation time of 390 +/- 82 minutes, intraoperative blood loss of 600 +/- 155 ml, and average of instrumented levels 7.4 +/- 1.3. The small incision thoracotomy group had an average operative time of (220 +/- 80) minutes, intraoperative blood loss of (320 +/- 120) ml, and number of instrumented levels 7.8 +/- 0.9. The curve correction rates of the two groups were not statistically significant (P>0.05). However, the operative time, blood loss, postoperative drainage, and early loss of correction differences showed statistical significance (P<0.05).

Levin et al. compared operative and radiographic results of mini-open thoracoscopically assisted thoracotomy with video-assisted thoracoscopic surgery for anterior release in thoracic scoliosis and kyphosis (10). Both approaches resulted in corrections that compare favorably with open thoracotomy except operation time. The authors suggested that a factor in choosing between these two minimally invasive techniques was the number of thoracic levels requiring release. Mini-open thoracoscopically assisted thoracotomy provided an excellent alternative to standard thoracotomy for four levels or less.

The effect of VATS (23 patients) and thoracotomy (32 patients) on lung functions used in AIS were investigated by Faro et al. The thoracoscopy group recovered their pulmonary function with FVC values being 101% +/- 11% of the preoperative FVC (2). The FVC values of the thoracotomy group also increased (93% +/-10% of preoperative values). The difference in FVC values was found to be statistically significant.

Health quality scores of patients with AIS who underwent anterior thoracoscopic instrumentation were better than with posterior instrumentation. Lonner et al. found a score close to 5 in the VATS group (maximum score) in most domains tested as opposed to a score close to 4 for the posterior surgery group (12). Patients were also highly satisfied with the outcomes 2 years after surgery in the Newton et al. series and the SRS Outcomes Questionnaire resulted in average scores for this domain of 4.8 +/- 0.6. (17)

Complications:

Major and minor complications were reported in the studies on VATS. The majority of complications can be divided into two groups; instrumentation-related complications and respiratory complications. Mucus plugs, atelectasias, hemo- and pneumothorax were the respiratory complications. Grewal et al. found a fewer number of infection-related complications in their VATS group which they attribute to smaller incisions (4). The rate of pseudarthroses was unacceptably high in the initial
experience of Picetti et al. The authors used autografts for this complication (20).

Karami et al. reported 21 patients with idiopathic scoliosis who underwent endoscopic thoracoplasty in their retrospective study. The mean age at surgery was 14.9 years (range 13-17 years). The average Cobb’s angle of the main scoliotic curve was 70 degrees (range 60 degrees - 85 degrees) with a follow-up period of 25 months (range 23-32 months). The mean number of resected ribs was 5 (range 4-7) and the mean length of the resected ribs was 4.2 cm (range 2.2-7 cm). The mean operating time of endoscopic thoracoplasty (including anterior release) was 65 min (range 45-108 min). The mean height of rib hump deformity was reduced from the preoperative value of 3.6 cm (range 2.5-5.5 cm) to 1.5 cm at the most recent follow-up. There was no significant postoperative thoracic pain (the mean VAS value was 8 mm). No major complications such as neurological deficit or significant hemorrhage occurred. One of the first patients presented with a hemothorax two months after surgery related to a fall (6).

Harvesting iliac crest bone graft is also problematic due to the increasing morbidity and adding another scar. Instrumentation with two rods is recommended to prevent implant failure and pseudoarthrosis. Weakening in shoulder function and neurological problems are the other reported complications.

**CONCLUSION**

VATS is a minimal invasive procedure feasible only with enhanced technology and developed personal skills. It allows similar results in anterior discectomy and anterior release to conventional open anterior surgery. Despite the obtained similar correction rate, the advantage of anterior thoracoscopic instrumentation over conventional anterior and posterior instrumentations has not been proven so far for the treatment of adolescent idiopathic scoliosis. Other prospective studies need to be conducted to determine the general applicability of this method.

**REFERENCES**


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