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Anterior thoracoscopic spine release in deformity surgery: a meta-analysis and review

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Abstract Videoassisted thoracoscopic surgery (VATS) allows the surgeon to perform an anterior thoracoscopic spine release for spinal deformities. It is an alternative to open thoracotomy. Several years after its introduction the present author gives an update on the indications, surgical techniques, results, and complications of this new technology. A meta-analysis of previously published papers is organized in tables in an attempt to answer all the questions and controversies that this technique has aroused. A series of ten selected articles were available for review, comprising a total of 151 procedures. No study had any long-term follow-up. Most series were pediatric and involved a variety of etiologies (mostly neuromuscular, adolescent idiopathic scoliosis, and Scheuermann's kyphosis). The surgical technique was for most authors a convex side approach in the lateral decubitus through four or more ports in the anterior or midaxillary line. Single lung ventilation was used in most cases. Posterior surgery was carried out the same day in most cases. The total number of discs excised varied between 4 and 7, but the quality of disc excision was rarely reported. Most authors carried out a spine fusion at the time of the disc release. The total VATS procedure lasted between 2 h 30 min and 4 h, depending on the series and the surgeon's previous experience. In most series curves were in the range of 55°–80°, with an average of 65°. The percentage of Cobb angle correction was 55%–63% after VATS and posterior spine fusion. For kyphotic deformities only one series had significant numbers to allow conclusions to be drawn. The mean preoperative Cobb angle was 78° and postoperatively the kyphosis was corrected to 44°. Length of hospital stay was quite similar in most series and was around 9 days. The cost of the VATS procedure was studied in one series and was found to be 28% more expensive than thoracotomy. The total complications reported were 18%; most were pulmonary complications with prolonged ventilatory support in patients with neuromuscular pathologies. The VATS procedure has been used with success in most series for pediatric curves (average Cobb angle of 65° or kyphosis of 75°). No report of the surgical outcome (balance, rate of fusion, rib hump correction, cosmetic correction, pain, and patient satisfaction) was available for any series. Further prospective study including these parameters will be required to determine the real benefit of such procedures to the patient, bearing in mind that the correction of spinal deformities is the result of the surgeon's experience, skill, and the available technology.

Key words Scoliosis · Endoscopy · Thoracoscopy · Thoracic disc · Videoassisted thoracic surgery

Introduction

The introduction of endosopic spine techniques for thoracic spinal surgery took place in 1993 through the work of Mack et al. [10]. Technically the goal of endoscopic surgery is to perform the same operations as the classical open techniques with less invasive methods. Over the last 7 years it has been used to perform anterior release of the spine to increase flexibility, anterior spine fusion, internal costoplasties [13], epiphysiodesis to prevent crankshaft phenomenon [3, 16, 17], and hemivertebra resection [12]. For the patient the advantages of video-assisted thoracic surgery (VATS) appear very attractive as, being less invasive, it results in less surgical trauma, less pain [9], possibly less morbidity, and less scarring. The benefits for the spine surgeon are not evident: VATS involves learning an unfamiliar technique, specific skills, often the assistance of a thoracic surgeon, possible more operating room time, and a sufficient volume of patients to acquire enough expertise to make the procedure worthwhile. The third party payer, the health care organization, and hospital administration will be mostly interested in the shorter hospitalization, decreased costs, and in some circumstances the publicity aspect of the new procedure. The goal of this study was therefore to present an update on endoscopic spine release in spinal deformities. In the light of these findings each surgeon will be his or her own best judge of whether it surpasses the conventional open techniques and whether it is applicable in his or her environment.

Material and methods

To determine the advantages of the VATS techniques we listed several questions (on the basis of our daily surgical experience) in different tables (see Tables 1–4). These questions relate to the number of published series, their scientific reliability, the technique used, and the results, morbidity, and complications of these techniques. To answer these questions we carried out a medline and literature search of all published articles as at August 1999. We entered the key words endoscopic spinal surgery and obtained 181 citations. With the key words thoracoscopic spinal fusion we obtained 21 citations; for thoracoscopic spinal release we obtained 11 citations and for complications of thoracoscopic spinal surgery we obtained 25 citations. We excluded all the animal studies and selected only the ones relating to patients and dealing entirely or partially with deformities of the thoracic spine. We excluded all review articles, keeping only prospective or retrospective clinical papers. Only abstracts written in English were selected. Dr Newton [16] kindly forwarded to us his latest paper accepted for publication in *Spine*. We were therefore left with ten papers[1] [5, 6, 8, 12, 14, 16–20] dealing either exclusively or partially with thoracoscopic anterior release in spinal deformities and their complications. We carefully reviewed each paper in its entirety to answer our questions. Where the answers were not provided we left a blank or an interrogation mark (Tables 1–4).

Results

Analysis of the published series

Among the ten published series dealing with the results or the complications of thorascopic anterior release, there were only two prospective studies, from Newton et al. [14, 16]; all the others were either retrospective or imprecise as to the nature of data collection. Only Newton et al. [14] compared a prospective, consecutive group of 14 patients with thoracoscopic release to a retrospective control group of 18 patients who had undergone open thoracotomy. Only three studies reported the length of their follow-up. The other authors either spoke of a "short follow-

[1] For clarity, the two papers by Newton et al. [14, 16] have been merged in our analysis

Table 1 Anterior thoracoscopic spine release: published clinical series (*AIS* adult idiopathic scoliosis, *CP/NM* cerebral palsy/neuromuscular)

Source	Type of study	Follow-up of (months)[a]	Mean patient age (years)[b]	No. of cases	Etiology of deformity: AIS	Scheuermann's kyphosis	CP/NM	Dysplastic	Congenital	Misc.
Holcomb et al. [5]	Retrospective	?	14.1	8	3	1	1	0	2	1
Huang et al. [6]	?	?	?	14	?	1	?	?	?	?
Kokoska et al. [8]	Retrospective	?	13.4	5	1	1	0	3	0	0
McAfee et al. [12]	Prosp./multicenter	?	19	24	?	4	?	?	?	?
Newton [14, 16]	Prospective	12	14	65	13	9	35	?	4	4
Papin et al. [17]	Retrospective	14	12.3	8	4	0	1	2	0	1
Regan et al. [18]	?	Short	48	4	2	2	0	0	0	0
Rothenberg et al. [19]	?	Short	(range 8–17)	20	?	?	?	1	4	?
Waisman & Sante [20]	Retrospective	32	16	3	2	0	0	0	1	0
Total				151	>25	>18	>37	>6	>11	>6

[a] Overall average 19 months, but most series have a follow-up of less than 18 months
[b] Overall average 16 years

Table 2 Anterior thoracoscopic spine release: surgical technique (*EMCM* extended manipulated channel method, *PSF* posterior spinal fusion)

Source	Positioning	Portals	Single-lung ventilation	Standard endotracheal tube	Vessel ligation	Number of discs released	Percentage % of disc excision	Fusion performed	Same-day PSF	Different-day PSF
Holcomb et al. [5]	Lateral decubitus	Midaxillary line: 4 ports	All	0	Not routine	4	?	Yes	5	3
Huang et al. [6]	?	EMCM: 3 ports	?	?	?	?	?	?	?	?
Kokoska et al. [8]	Lateral decubitus	3 or more ports	5	0	Yes	7	Partial	Some yes, others no	5	0
McAfee et al. [12]	Lateral decubitus	Ant. axillary line (4 ports)	?	?	?	?	?	?	?	?
Newton [14, 16]	Lateral decubitus	Ant. axillary line (4 ports)	64	0	Yes	6.5	Complete	Yes (auto-/allograft)	63	1
Papin et al. [17]	Prone & lat. decubitus	4–5 ports	8	0	Yes	4	Partial	Yes	8	0
Regan et al. [18]	Lateral decubitus	Ant. axillary line (4 ports)	All	0	No	4.7	Partial	Yes (iliac crest)	Yes	0
Rothenberg et al. [19]	Lateral decubitus	3–7 ports	3	17	No	7	?	Yes (allograft)	20	0
Waisman & Sante [20]	Lateral decubitus	Ant. axillary line (4 ports)	3	0	?	4	Partial	No	0	3
Overall	Lateral decubitus convex approach	At least 4 portals for scoliosis; for kyphosis 3 may be enough	Yes	Rarely	Controversial	4–7 discs	Imprecise	Most do	Most do	Most do not except if problem

up" or were imprecise as to it. All series were mostly pediatric except in the preliminary report of Regan et al. [18]. Only three series had at least 20 cases. The overall number of cases published was 151, and the predominant etiologies were neuromuscular, adolescent idiopathic scoliosis, and Scheuermann's Kyphosis (Table 1).

Analysis of surgical techniques

The technique used was almost uniformly a convex side approach with the patient in the lateral decubitus position, with single lung ventilation, and four or more portals along the anterior or midaxillary line, except for kyphotic deformities where three portals were enough (Table 2). The posterior surgery was done the same day in most cases. Little consensus existed as to whether it was necessary to ligate the intercostal vessels. The number of discs excised varied between 4 and 7. The percentage of discs excised was not clearly stated in most series. Most authors performed an anterior fusion at the time of the thoracoscopy.

Analysis of results

Operative time varied between 1.5 h and and 5 h (Table 3). In the larger experience of Newton et al. [16] a significant learning curve appeared to exist, but once this was surmounted operative time was about 2.5 h. However, the time for the whole procedure (thoracoscopy and posterior spine fusion) remained in the 10-h range in most series. In most scoliotic deformities the curve was in the range of 55°–80° (average 65°) and the postoperative correction was in the 25°–37° range, representing a 56%–63% correction. The time spent in hospital for the combined procedure was around 9 days. Newton et al. [14], calculating the cost of the thoracoscopic procedure, found it to be 28% more expensive than classical open thoracotomy.

Analysis of complications

Among 151 cases we found 27 complications (18%) (Table 4). Most of these complications did not seem to have an impact on the final result. However, a high incidence of prolonged ventilatory support was observed, mostly in neuromuscular patients, as well as a significant number of pulmonary complications. Only three patients suffered major bleeding during VATS.

Discussion

Various observations can be drawn from this literature review:

Table 3 Anterior thoracoscopic spine release: results (*VATS* video-assisted thoracoscopic surgery, *PSF* posterior spine fusion)

Source	Operative = time (min)		Scoliosis			Kyphosis			Time in hospital (days)	Cost of VATS vs open thoracotomy
	VATS	Total VATS + PSF	Mean preop. Cobb angle (°)	Flexibility (%)	Postoperative Copp angle (°)	Cobb correction (%)	Mean preop. Cobb kyphosis	Postop. Cobb kyphosis (°)		
Holcomb et al. [5]	174	?	?	?	?	?	–	–	?	?
Huang et al. [6]	?	?	?	?	?	?	–	–	?	?
Kokoska et al. [8]	305	711	?	?	?	?	–	–	8.6	?
McAfee et al. [12]	?	?	?	?	?	?	–	–	?	?
Newton [14, 16]	161	?	62[a]	?	25	56	78	44	9.5	28% more
Papin et al. [17]	240	430	66	37	23	63	–	–	9.9	?
Regan et al. [18]	210	603	92	?	?	?	–	–	9	?
Rothenberg et al. [19]	106	?	?	?	?	?	–	–	?	?
Waisman & Sante [20]	90	?	95	10	37	63	–	–	?	?
Average	184	581 (=10 h)	78 (mean of all series;	–	25–37	60	78	44	9.1	28% more expensive

[a] In his first series [14] Newton had an average Cobb angle of 84°. In his second series [16], which includes the first one, the average scoliotic curve was 62°

Table 4 Anterior thoracoscopic spine release: morbidity and complications. Among 151 cases the total number of complications was 27 cases (18%) (*URTI* upper respiratory trait infection, *NM* neuromuscular)

Source	Blood loss (ml)	ICU stay (days)	Chest tube (days)	Major bleeding (> 2000 ml)	Prolonged ventilatory support	Pulmonary complications	Neurologic complications	Intercostal neuralgia	Miscellaneous	Aborted procedure or conversion to open thoracotomy
Holcomb et al. [5]	203	?	?	1	?	0	0	?	0	0
Huang et al. [6]	?	?	?	0	2	?	0	4[a]	1 Chylothorax	0
Kokoska et al. [8]	?	1	6.8	0	0	0	0	?	0	
McAfee et al. [12]	94	?	?	0	?	?	1 transient leg weakness	6[b]–	–	0
Newton [14, 16]	301	2.3[c]	3.9	1	6 NM patients	1 URTI, 2 pleural effusion	0	?	1 Superficial infection, 1 chylothorax	2
Papin et al. [17]	200	0,5	4.4	1	0	2 Pneumothorax	0	?	–	1
Regan et al. [18]	433	1.4	1.7	0	0	1 Pleural effusion	0	?	1 Tachycardia	0
Rothenberg et al. [19]	?	1.8	2.2	0	2[d]	?	0	?	?	0
Waisman & Sante [20]	?	0	1	0	0	0	0	?	0	0
Average	246 ml	1.4 days	3.3 days							
Total				3	10	6	1	?	4	3

[a] 4 Cases of transient intercostal neuralgia from a group of 90 miscellaneous VATS cases
[b] 6 Cases of transient intercostal neuralgia from a group of 78 miscellaneous VATS cases (anterior release, thoracic discectomy, corporectomy)
[c] Prolonged ICU only observed in neuromuscular patients
[d] 1 Tracheostomy and 1 prolonged ventilatory support

Indications for thoracoscopic spine release in scoliotic deformities

Seven years after its introduction, thoracoscopic spine release is not yet widely practised compared with the large number cases of isolated posterior spinal fusion and/or isolated anterior spine instrumentation; we found only 151 cases of such releases reported in the literature [5, 6, 8, 12, 14, 16–20]. This is not surprising as an excellent result can be achieved in most scoliotic deformities with straightforward posterior or anterior instrumentation. Most of the releases performed so far have been carried out in pediatric series where the spine is more flexible than in the adult. If the indication for anterior release are rigid curves above 75° which side-bend to less than 50°, as is commonly agreed, it may be asked whether all these anterior releases were really indicated (average Cobb angle in the 151 cases: 65°). In pediatric deformities the risk of crankshaft phenomenon is real for immature patients, and there is no doubt that an anterior epiphysiodesis performed at the same time as the posterior fusion has a role. In such cases it is preferable to speak of anterior thoracoscopic epiphysiodesis rather than release. However, most series apart from that of Papin et al. [17] dealt with already fairly mature patients with a mean age of 14 years. So the debate is still open as to the need for anterior release for flexible pediatric curves in the 60°–75° range if there is no risk of crankshaft. Major curves of more than 85°–90° have been addressed in the series of Waisman and Saute [20], the initial series of Newton et al. [14], and that of Regan et al. [18]. However, these series had too small numbers of cases to draw any conclusions. Papin et al. [17] and Newton et al. [16] in their latest report consider that very large deformities may be better addressed through an open thoracotomy because of the small distance between the chest wall and the spine and the increased technical difficulties of performing an adequate release. In such conditions, for major deformities the classical sequence of open anterior release, halo distraction, and posterior fusion may still be indicated. Finally, no series has addressed the most difficult cases of anterior releases – osteotomies of the thoracic spine of deformities such as ankylosing spondylitis. We could only find a case report by Dickman and Mican [2] where the thoracoscopy was used successfully to decompress a myelopathic patient with a post-traumatic kyphotic deformity.

Indications for thoracoscopic release in kyphotic deformities

In Scheuermann's disease the classical indications for surgery are curves of more than 75°. The treatment of the deformity is still controversial and the need for anterior release of flexible curves is questionable given the availability of modern segmental instrumentation and the possibilities of posterior shortening procedures through complete facetectomies. However, the risk of loss of correction and pseudarthrosis persuades many authors to perform an anterior release. In Newton's largest experience [16] of 9 cases the results showed normalization of the kyphosis. The spine is easier to access with VATS in kyphotic deformities than in scoliosis. The number of discs released is higher than in scoliosis, and the number of portals is smaller. In such cases, therefore, VATS may represent an excellent alternative to open thoracotomy. The debate is still open, however, in relation to major rigid curves requiring extensive discectomies at multiple levels.

Surgical technique

Although different release techniques are possible – in the prone position, in the lateral decubitus, from the convex, or concave approach – most authors use the lateral decubitus position from the convex side with single-lung ventilation. The major advantage of this is the possibility of converting to an open thoracotomy if necessary. As to vessel ligation, this leads to better exposure of the spine, as reported by Newton, and in our opinion it allows more complete discectomy. The concave approach, used in one case in the Papin series [17] and by other surgeons in unreported series, seems to be technically very demanding. The learning curve has a definite impact on the operative time and on the ability to perform more discectomies as reported by Newton et al. [16] For Newton the operative time for VATS release (less than 2.5 h) is similar to that for the open procedure. As to the surgical endoscopic technique used to approach thoracolumbar curves as described by Burgos et al. [1], we took that to be beyond the scope of this review, which deals specifically with thoracic deformities.

Results

In the comparative study by Newton et al. [14], the VATS techniques gave the same results as open procedures in achieving spinal flexibility. This was assessed by the average percentage of correction and was reported in two further series [16, 21]. It was further confirmed in two animal studies comparing open and endoscopic procedures [15, 21] with similar results on spinal flexibility. The extent of discectomy was not clear in any of the published human series. In a comparative animal study of endoscopic versus open release Huntington et al. [7] found no significant statistical difference in the extent of disc excision between their two groups, with a percentage of disc exicision of 67.8% in the thoracoscopic group and 76.1% in the open group. However, the animal studies did not report on scoliotic deformities, and the lack of 3D visualization of the disc space and our own experience [17] make, in our mind, a complete 360° discectomy more difficult and more dangerous with VATS technique than with conventional thoracotomy.

Complications

Complications, both major and minor, were reported in 18% of the cases. Newton et al. [16] compared their first 14 patients with thoracoscopic spine release to a similar group of 18 patients with open release. According to them the complication rates were similar in both groups (5 in the thoracoscopic group, 3 in the open thoracotomy group). Grossfeld et al. [4] give a very detailed report of the complications of classical anterior spinal surgery in 175 children who underwent combined anterior and posterior surgery. Major complications were seen in 6.3% and minor complications in 22.3%. This seems to be slightly higher than the complication rates reported in our meta-analysis of VATS cases, but differences in patient selection, etiologies of the spinal deformities, and severity of the curves may account for an increased incidence of complications. We therefore cannot tell whether morbidity is decreased or increased with the VATS procedures. As to the rate of complications in adults, there is no large series of VATS cases from which to draw any conclusions.

Conclusions

Seven years after the initial report of VATS for spinal deformities [10], this first meta-analysis shows that the procedure has been effective in the correction of spinal deformities mostly in pediatric cases. Only a limited number of centers have acquired wide experience with such releases. They report a correction rate similar to that with open thoracotomy, with rates that are acceptable, yet not very different from those seen with open release. From their experience VATS seems best indicated to treat moderate curves (in the 55°–75° range). Larger curves seem to be best addressed by conventional methods.

We hope this analysis will help each individual surgeon to decide, on the basis of his own experience, and his own ability to correct spinal deformities with the instrumentation with which he is familiar in the environment in which he is working, whether a VATS release is indicated. For each specific curve he will have to decide between a posterior spine fusion with or without thoracoplasties, an anterior-only spinal instrumentation, or an anterior release (either thoracoscopic or open) followed by a posterior instrumentation. Further prospective studies with longer follow-up, including the classical parameters of scoliosis correction in terms of balance, rib hump correction, cosmesis, rate of fusion, function and patient satisfaction, will be required before we can determine the real benefits of thoracoscopic release for the patient.

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