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Early changes in pulmonary function following thoracotomy for scoliosis correction: the effect of size of incision

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Abstract It is generally believed that minimal access surgery may produce less change in pulmonary function than conventional open thoracotomy for scoliosis correction. Though there is considerable literature regarding changes in pulmonary function tests (PFT) after thoracotomy, there is scant data available regarding the effect of the magnitude of thoracic wall disruption on pulmonary function, particularly in the early postoperative weeks. This study aims to evaluate the effect of the size of incision on pulmonary function after anterior release and fusion in patients with moderate thoracic curves due to adolescent idiopathic scoliosis. The study group was made up of 19 patients with thoracic curves due to adolescent idiopathic scoliosis. The subjects had had thoracotomy for anterior release, followed by posterior instrumentation and fusion at a second sitting. The ten patients who had had conventional, large thoracotomy were placed in group A and the nine minimal access cases in group B. PFTs consisting of volume (FVC) and flow (FEV1) were obtained before the anterior release, 2 weeks later (before the posterior instrumented fusion), and 3 months after

the posterior fusion. The degree of deformity in the sagittal and the coronal plane preoperatively and postoperatively were measured and documented. The mean preoperative pulmonary function was significantly less than the predicted values for both patient groups. There was a decline in the postoperative pulmonary function (both percentage predicted value and absolute value) in both groups at 2 weeks and at 3 months. The deterioration of pulmonary function was less in the small-thoracotomy group, but this difference between the groups was statistically significant only for the 2-week values. Our study shows that there is significant pulmonary function restriction even in patients with moderate thoracic curves. There was a lesser decline in pulmonary function in the minimal-access group, as compared with the standard thoracotomy group, but this difference was only in the early postoperative period and became insignificant by 3 months.

Keywords Pulmonary function tests · Thoracotomy · Anterior release · Adolescent idiopathic scoliosis · Surgical correction

Introduction

The evaluation of pulmonary function in spinal deformity has always been considered important because of

the associated thoracic-wall distortion. Pulmonary function is documented to be restricted in severe thoracic scoliosis and in thoracic lordosis [3, 14, 15]. Earlier reports of pulmonary function tests (PFTs) taken after

adolescent idiopathic scoliosis (AIS) correction using Harrington rods were conflicting, but a recent meta-analysis showed a modestly improved pulmonary function [7]. Improved pulmonary function has been reported using posterior segmental instrumentation as well [9]. Better correction of the coronal and sagittal plane deformities is now being achieved by anterior release and newer instrumentation strategies. However, thoracotomy or thoracoplasty is associated with an initial worsening of pulmonary function, as reported by many authors [6, 11, 12, 13]. In recent years video assisted thoracoscopic surgery (VATS) and minimal access spine surgery have been increasingly used for deformity corrections as well. It has been suggested that these approaches significantly reduce the incidence of postoperative pulmonary dysfunction [2, 5]. Such claims obviously need to be substantiated by appropriate prospective, controlled trials. As a prelude to such a larger study, we retrospectively reviewed the results of pulmonary function tests in two groups of our patients—an earlier group of patients who underwent conventional thoracotomy and a later group who underwent the mini-thoracotomy that has now become the standard practice at our center.

Materials and methods

We retrospectively evaluated the PFTs, X-rays and anesthesia records of patients who underwent two-stage anterior and posterior spine fusion for thoracic curves due to adolescent idiopathic scoliosis. The indication for combining anterior release with the posterior instrumentation for AIS at our center is the presence of two or more of the following criteria:

1. Risser grade 1 or less
2. Girl within 6 months of menarche (The menarchal age of girls in South India (Dravidian race) is 13–14 years)
3. Cobb angle more than 75°
4. Cobb angle correction by less than 30% on side-bending X-rays

These criteria have evolved based on 2 decades of our experience performing scoliosis surgery in our population. The limited anaesthetic and intensive care

resources available at our center preclude a prolonged, combined anterior and posterior surgery in one sitting.

Over a 2-year period from June 2001 to June 2003 there were 23 patients who underwent this surgery. The data were complete for 19 patients. Of these, ten patients (group A) had standard large thoracotomy incisions (about 15–20 cm size) and nine (group B) had minimal access incisions (5–7.5 cm size). We have been using a Bookwalter retractor system (Codman, USA) for the mini access thoracotomy. Standing AP and supine-side bending X-rays were taken in all the cases and the curve type and coronal and sagittal measurements were recorded. Measurements were taken according to the Cobb method. Kyphosis was measured from T5 to T12. The age, sex and curve type of the patients, number of ribs removed and number of disks excised is presented in Table 1. There was no statistically significant difference between the groups for the preoperative or postoperative curve measurements (Table 2).

All surgery was done at this hospital by one of the two senior authors. Until August 2002, we were using the standard thoracotomy approach for anterior release and fusion. From September 2002 we started using multiple (two or three) small thoracotomies, each of 5–7.5 cm in length. In both approaches, the procedure consisted of discectomy, removal of the cartilaginous endplate, and fusion with rib graft mixed with synthetic hydroxyapatite. The rib heads on the convex side were removed at all the levels where the discectomy was done. The thoracotomies were closed with a single intercostal drainage tube (ICD tube) that was removed after 2–3 three days in all cases. Postoperatively, all patients had chest physiotherapy, which included intermittent positive pressure ventilation and incentive spirometry. Chest X-rays were taken routinely in the postoperative period and patients were closely monitored for any pulmonary complications such as hemothorax or pneumothorax, lung collapse or pneumonia.

In the second stage (9–20 days after the first surgery) all the patients underwent posterior spinal instrumentation and fusion with either the Universal Spine System (Mathys, India) or an indigenous hook-screw system. During the surgery the convex-side rib hump was excised and used as graft (no additional iliac crest bone was taken). Epidural analgesia is routinely used

Table 1 Age, sex, type of curve, number of ribs excised and number of disks excised

Group	Age (years)		Sex		King type			No. ribs excised in anterior approach		No. disks excised
	Mean	Range	M	F	2	3	5	1 rib	2ribs	(mean)
A	15.5 ± 1.78	13–18	4	6	6	4	0	4	6	4.4
B	14.89 ± 2.89	11–19	1	8	5	3	1	1	8	4.9
Total	15.21 ± 2.32	11–19	5	14	11	7	1	-	-	-

Table 2 The mean preoperative and postoperative Cobb angle values for scoliosis and kyphosis

		Scoliosis°	Range°	Kyphosis°	Range°
Allpatients	Preop	59.32	42–89	24.87	4–55
	Postop	21.00	6–42	21.07	2–37
Group A	Preop	57.70	47–70	20.83	4–46
	Postop	19.50	11–26	20.67	2–34
Group B	Preop	61.11	42–89	27.56	9–55
	Postop	22.67	6–42	21.33	11–37

postoperatively for all deformity cases during the first 48 h. Postoperatively, the patients were allowed to be mobile after 2 days and were advised to use thoracolumbosacral orthosis (TLSO), only during ambulation, for 3 months. They were reviewed at 6 weeks, 3 months, 6 months and 1 year.

There was no significant pre-existing pulmonary disease in any of the patients, except history of mild bronchial asthma in one patient. None of our patients smoked. PFTs were recorded preoperatively, and they were repeated before the second-stage surgery and at 3 months postoperatively. Both volume (forced vital capacity, FVC) and flow (forced expiratory volume, FEV1) were recorded each time. The second PFT study was done on average 12.1 days (range 9–20 days) after the first stage in group A and on average 13 days (range 9–20 days) in group B.

The PFTs were done using the microQuark spirometer (Cosmed, Italy). The data were analysed using Student *t* tests with SPSS software.

Results

There was no statistically significant difference in the sagittal and coronal plane correction obtained between the two groups. There was a statistically significant reduction in the preoperative pulmonary function in all the patients (Table 3) when compared with the values predicted for their age, sex, and body surface area ($p=0.000$).

There was a decline in FEV1 and FVC values at 2 weeks and 3 months after the thoracotomy in both groups (Table 4). It could be seen that at both of the above time periods, the pulmonary function decline was lesser in the small thoracotomy group. This fact was

statistically significant at 2 weeks for both FEV1 and FVC values ($p=0.043$ in both cases). The differences between the groups at 3 months regarding the PFT decline were statistically not significant ($p=0.062$ for FEV1 and $p=0.074$ for FVC).

Discussion

The advantages of minimal access anterior surgery for spinal deformity are said to include a reduction in deterioration of pulmonary function [2, 5]. There is little evidence to substantiate this claim. Meyer has documented that VATS produces minimal changes in the PFT [2, 5]. Newton and colleagues [11] have reported that those patients who underwent a thoracoscopic anterior instrumentation and fusion for AIS had less decline in FVC at 3 months compared with the group that underwent open thoracotomy and instrumentation. Vedantam [13] and Graham et al. [6] in their studies have found that the initial decline in PFT values seen at 3 months following thoracic wall disruption recovers by 2 years. Graham also found that the PFT decline was slightly more with double thoracotomy as compared with single thoracotomy. Leong considers that aggravation of the mechanical inefficiency of the scoliotic spine by surgical instrumentation and fusion is one of the factors leading to deterioration in postoperative pulmonary function [10]. This factor, combined with the effect of rib resection on the bony chest cage and the soft-tissue dissection, could account for the persistent PFT reduction after AIS corrections. A significant portion of the early PFT changes is thought to be due to the pain due to dissection of muscles on the chest wall. In the less-invasive thoracotomies, the latissimus dorsi and the pectoralis major are not cut, but the serratus anterior and the intercostals are. All these muscles are violated in the standard thoracotomy. Burd et al. [4] have reported that the effect of thoracic muscle disruption fully recovers by 3 months after a thoracotomy for anterior spinal fusion. We may therefore presume that the effects of magnitude of tissue dissection also may cease by 3 months.

In the study presented we have studied the effect of the magnitude of chest cage disruption on pulmonary function. The pulmonary functions—both volume (FVC) and flow (FEV1)—decreased significantly in the

Table 3 Mean forced expiratory volume (FEV1) and forced vital capacity (FVC) (percentage predicted values and absolute values in litres)

	FEV1			FVC		
	Preop	2-week	3-month	Preop	2-week	3-month
Allpatients	67.12%1.83 l	45.31%1.23 l	48.42%1.34 l	71.22%2.16 l	45.67%1.38 l	50.67%1.56 l
Group A	74.02%2.05 l	47.72%1.31 l	50.79%1.41 l	78.41%2.43 l	47.96%1.47 l	54.2%1.68 l
Group B	59.46%1.58 l	42.63%1.14 l	45.79%1.25 l	63.23%1.87 l	43.12%1.28 l	46.76%1.43 l

Table 4 The mean decline in postoperative PFT values (*FEV1* forced expiratory volume *FVC* forced vital capacity; absolute values in litres and percentage predicted values) in both groups of patients

	2 weeks		3 months	
	FEV1	FVC	FEV1	FVC
Group A	0.74 126.3%	0.96 130.45%	0.64 123.23%	0.75 124.21%
Group B	0.44 116.82%	0.59 120.11%	0.33 113.67%	0.44 116.48%
<i>P</i> value for absolute values	0.043	0.043	0.062	0.074
<i>P</i> value for percent predicted values	0.054	0.041	0.128	0.177

immediate postoperative period and improved later at 3 months. However, they remained lower than the preoperative values. Both absolute values and percentage predicted values showed the same trend. We also found that the decline in FEV1 and FVC were less pronounced in the small thoracotomy group. The difference between the decline in PFT values of groups A and B was statistically significant only at 2 weeks. There was no statistical significance in the difference at 3 months. On the basis of this study we can hypothesise that lesser chest-wall disruption by thoracoscopic surgery may produce better pulmonary function in the immediate postoperative period. After comparing our results with those of Newton et al. [11], we conclude that the effect of chest wall disruption on PFT occurs more in the early postoperative period, and the difference tends to diminish with time.

The limitations of our present study are that it is retrospective and the sample size is small. Additionally, one of the drawbacks of conducting a PFT study in the

immediate postoperative period is the limitation of the respiratory efforts due to pain in the first postoperative week [6, 8]. Another variable that is reported to have an effect on pulmonary function is the duration of one-lung ventilation employed during the anterior release surgery [1]. We are unable to provide exact data in this regard, but it is expected that the duration is more with the small thoracotomy group.

Conclusion

In adolescent idiopathic scoliosis there is significant pulmonary function restriction even with moderate thoracic curves. There seems to be a direct relation between the size of the chest-wall incision and the postoperative pulmonary dysfunction—the smaller the incision, the lesser the pulmonary dysfunction. However, by about 3 months the advantages of a small thoracotomy with respect to PFT become insignificant.

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