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Lung Functions after Correction of Scoliosis Angle

Hasan-Allah Sadeghi [1], Mohammad Mehdi Zahmatkesh [2], Amin Ehteshami Afshar [2], Nazita Paziraee [2]

[1] Department of Pulmonary Medicine, Rajaee Heart Center , [2] Department of Pulmonary Medicine, Iran University of Medical Sciences (IUMS),TEHRAN-IRAN.

ABSTRACT

***Background**: In this study we evaluated lung volumes, volume changes relative to Cobb angle and correlation of volume changes with Cobb angle changes before and after the surgery.*

***Materials and Methods**: Eighteen non-smoker patients with idiopathic scoliosis were included in this descriptive observational study. Cobb angle, lung volume and flow were measured before and after the surgery. To assess height and weight changes during the follow-up period, we used the percent relative to normal (percent predicted) instead of absolute volumes.*

***Results**: Eighteen of 30 selected patients were included. The mean follow-up period was 34.5±19.6 months. Dynamic volume changes of lung were: VC= -13.4 SD=8.6 (p<0.005); FVC=-9.22 SD=14 (p<0.001); FEV1=9.8 SD=15 (p<0.001). There was a weak correlation between the mean value of dynamic volume changes and the mean changes in Cobb angle after the surgery. There was a weak correlation between Cobb angle and dynamic volume of lung before the surgery.*

Conclusion**: In this study there was a significant decrement of dynamic lung volumes after corrective surgery for thoracic curve scoliosis. **(Tanaffos 2008; 7(4): 27-31)

***Key Words**: Cobb angle, Scoliosis, Forced vital capacity, Vital capacity, Forced expiratory volume in 1 second*

INTRODUCTION

Patients with a scoliosis angle of above 65° are predisposed to respiratory complications and failure (1-4). Surgery is recommended in patients with severe lung restriction and in adolescents with a progressive scoliosis angle of above 45^{o} (1,5-7). Surgical correction of scoliosis has shown different results (5-13) on lung volume.

Correspondence to: Sadeghi HA
Address: Department of Pulmonary Medicine, Rajaee Heart Center, Iran University of Medical Sciences, Tehran-Iran.
Email address: sadeghi194@yahoo.com
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Lung volumes increase after birth up to the age of 25- 30 years old. Increase in lung volumes up to age 8 is mostly related to the increased number of alveoli. Thereafter is related to the increase in the alveolar size. Diseases that affect the thoracic cage may result in a decrease in lung volumes. Kyphoscoliosis causes chest wall deformity along with atelectasis of some parts of the lung and abnormal motions of the thoracic cage. These changes may affect normal growth of the lungs.

The effect of surgical correction on the pulmonary function of patients with adolescent idiopathic scoliosis is controversial. The related scientific literature has shown improvement, decline, or no change in the pulmonary function after surgical correction of idiopathic scoliosis(1,9,13-22).

Theoretically, lung volumes decrease after thoracic surgery for scoliosis with classic anterior and posterior spinal fusion initially due to the surgery itself. Nevertheless, an increase in lung volume in the long-term has been reported (1,5,14,19).

A decrease in lung volumes has been reported in the first 2 years after correction, especially in the first 3 months (5,7,9,11-13). A review of the existing literature also demonstrates that some studies have reported an increase in lung volumes (13-19). Other studies have shown no changes or decreases in lung volumes (20-22). Surgical methods affect the results, and today there is overwhelming evidence in favor of it (5,9,10,11,13-17). Anterior spinal fusion (ASF), especially with thoracoplasty, leads to a significant decrease in lung volumes (10, 16, 18). Posterior spinal fusion (PSF) and thoracoscopic methods are less invasive and conserve lung volumes better (13-15). An improvement in the volume may be minimal despite a good correction of Cobb angle, and some changes may be irreversible (8,12).

The present study was designed to evaluate the long-term effect of scoliosis corrective surgery on lung volumes and flows.

MATERIALS AND METHODS

This descriptive observational study evaluated patients who had undergone successful surgery for scoliosis between 1992 and 2002. They had Cobb angle and pulmonary function test (PFT) measurements before the surgery and also underwent surgery at least 6 months prior to the commencement of this study with no significant intrathoracic complications like hemothorax or atelectasis. New chest x-ray and PFT were obtained. Cobb angle was measured based on Cobb method on the coronal axis in upright position. Volumes were measured by CHESTAC Spirometer (Japan). Arm span was used instead of height and measured in upright position with upper extremities extended at the axis of the shoulder. All myopathic and traumatic scoliosis cases were excluded.

All PFTs met the "American Thoracic Society" (ATS) standards for operator and instruments. Since most patients were in the growing ages, percent-predicted values were applied for comparison and analysis, instead of absolute values. Analyses were carried out with SPSS software Ver. 11.5 and compared with a paired t-test analysis. The correlation between the volumes and Cobb angle was obtained via a linear regression method.

Thirty patients were selected. Twenty-one patients were recruited successfully, and 18 patients did acceptable pulmonary function tests based on the ATS criteria. All dynamic volumes including forced vital capacity (FVC), slow vital capacity (SVC), forced expiratory volume in the first second (FEV1), forced expiratory flows (FEF25, FEF75 and FEF25-75), and percent of FEV1/ FVC were also measured and evaluated.

RESULTS

Demographic findings of these 18 patients were obtained. All patients had idiopathic scoliosis. Twelve patients were females and 6 were males. The mean age was 17.60±6.30 yrs (range 8 to 34 years) at the time of operation. Anterior spinal fusion (ASF) and posterior spinal fusion (PSF) were performed in 16 cases, and 2 cases had posterior spinal fusion alone. In 2 patients, ASF and PSF with humpectomy were carried out. The mean arm-span value at the time of operation was 152.53±16.41 cm (172cm upper and 103 cm lower). The mean Cobb angle value was 82.22±19.34 (range 50-125) before the operation. The mean Cobb angle changes was 24.55±16.09 (range 3- 64). The mean post-op Cobb was 58.44±19.82. The mean follow-up period was 34.5±19.69 months. Table 1 depicts the details of lung volumes and percent-predicted values and its related P-value.

Comparison of lung volumes and percent predicted values for FEV1, FVC, SVC, and peak expiratory flow rate (PEFR), forced expiratory flows (FEF25, FEF75 and FEF25-75) and percent of FEV1/ FVC have been demonstrated in figure 1-3.

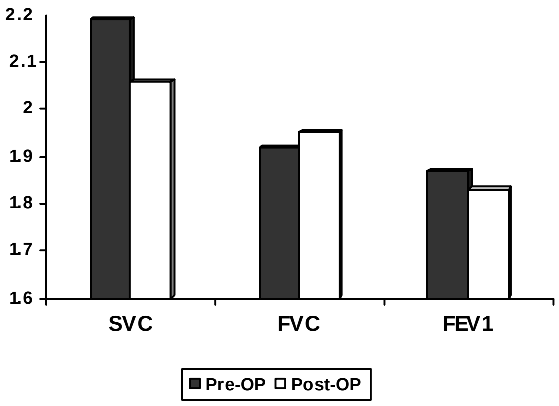

Figure 1. Lung volumes (liters) in 18 patients with idiopathic scoliosis before and 3 years after anterior and posterior spinal fusions.

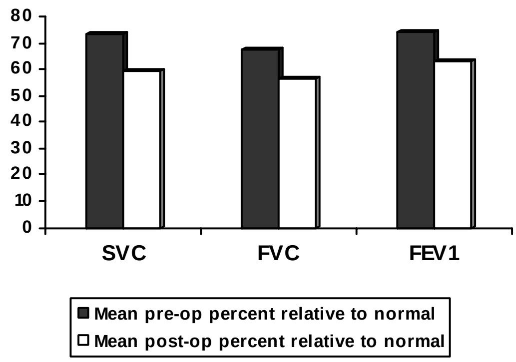

Figure 2. Mean pre-op and post-op values (percent predicted) of slow vital capacity (SVC), forced vital capacity (FVC) and forced expiratory volumes in the first second (FEV1) in 18 patients with idiopathic scoliosis.

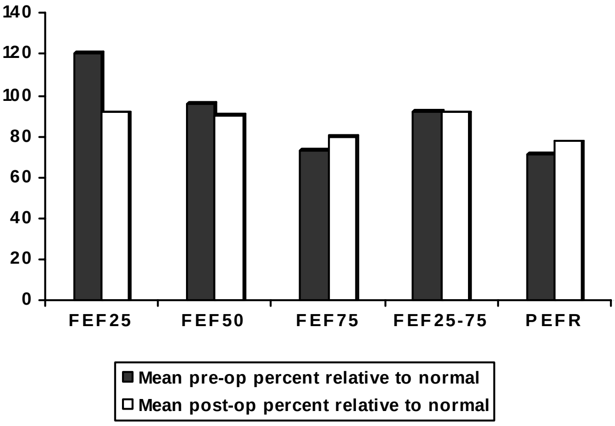

Figure 3. Mean pre-op and post-op values of forced expiratory flow at 25, 50 and 75 percent of vital capacity, FEF25-75 and peak expiratory flows in 18 patients with idiopathic scoliosis.

Table1. Pulmonary function tests, total value and percent predicted in 18 patients with Kyphoscoliosis and related p-value.

	Value	Percent	Value	Percent	P-value (liter)	P-value (%)
FEV1	1.87	73.55	1.83	63.79	NS*	0.001
FVC	1.92	66.26	1.95	57.06	NS	0.001
SVC	2.19	73.87	2.06	59.93	NS	0.005
FEF25	1.83	90.82	2.02	106.18	NS	NS
FEF50	3.58	91.93	3.70	89.89	NS	NS
FEF75	4.69	79.94	4.96	79.62	NS	NS
FEF25-75	3.24	95.17	3.56	91.66	NS	NS
FEV1/FVC	-	97.55	-	94.45	0.07	NS
PEFR	5.08	80.98	5.28	77.37	NS	NS

*NS: Non-Significant

DISCUSSION

Most patients in the present study were under 20 years of age; however, despite the insignificant changes in the absolute values, the percent-predicted values declined. In other words, the patients had lung values below the predicted level.

Our study showed no significant changes in long volume after surgery but percent-predicted value decreased. As seen in Table 1, 9.76% ($p<0.001$) decrease in FEV1, 9.2% in FVC ($p<0.001$) and 13.94% in SVC ($P<0.005$) was evident.

Gazioglu et al. showed a 17% increase in the absolute lung value (19), whereas Gagnon et al. (1) reported 10% and 12 % increases, respectively. The Pehrsson's (5) study also demonstrated an improvement in the lung function 25 years after post-spinal fusion. There are; however, opposite results reported in the literature. For instance, Makley and Gucker studies showed no changes in the lung volume (21, 22). Westate showed a 10% decrease in the lung volume. They estimated their patients' height based on the scoliosis angle (20).

We hypothesize the followings for these opposite result:

Firstly and foremost, it is the study design that may influence the results; difference in the method of height estimation, difference in the age distribution of patients, consideration of absolute or percent-predicted values, and difference in the techniques of measurements and calculation of predicted values can all affect the final results significantly. As shown in Table 1, if we consider absolute values of patients, then all values increase significantly. But, since most patients were in the growing age and there was no control group, this increase in value, is not compatible with surgical effect alone.

Secondly, the type of surgery is a very important factor. Spinal fusion with posterior approach and use of thoracoscopic methods for anterior spinal fusion confer better results. Most of our patients had anterior spinal fusion (ASF) plus posterior spinal fusion (PSF) with one thoracoplasty. Recently, Vedantam (10) linked the differences in the pulmonary function after spinal fusion surgery to different types of surgical approaches; patients without rib cage disruption had a remarkably greater improvement in their lung function 2 years after surgery than the ones in whom the rib cage was disrupted.

Timing of the operation may also affect the final results. If surgery is done at an earlier age, it may confer more conservation of the lung volumes. We tried to categorize patients based on age and Cobb angle correction value. There was no significant difference based on age and delta scoliosis angle.

In this study, the correlations between Cobb angle and FEV1 and VC as well as other variables were insignificant both for pre-op and post-op values ($r = -0.233$). We could not predict the lung volumes correctly based on Cobb angle on the coronal plane.

In this study, forced expiratory flows at 75% of thoracic volume (FEF75%) and PEFR decreased and FEF25%, FEF 50%, and mid-flows (FEF25-75%) increased after the operation (Table 1). Despite diverse changes in lung flows at high and low thoracic volume none of the changes were statistically significant and there was no correlation with scoliosis angle improvement.

In conclusion, lung volumes including FVC, SVC and FEV1 decreased about 9-13% ($P<0.001$) 2 years after ASF and rib resection. Therefore, scoliosis surgery does not confer a better conservation of lung volumes despite a significant improvement in Cobb angle. Less invasive procedures with PSF and thoracoscopic approaches may yield better results.

The correlations between Cobb angle and lung volumes were weak before and after operation. We cannot precisely predict lung volumes based on Cobb angle in idiopathic scoliosis.

REFERENCES

1. Gagnon S, Jodoin A, Martin R. Pulmonary function test study and after spinal fusion in young idiopathic scoliosis. ***Spine*** 1989; 14 (5): 486- 90.
2. Lindh M. Energy expenditure during walking in patients with scoliosis. The effect of surgical correction. ***Spine*** 1978; 3 (2): 122- 34.

3. Barrios C, Pérez-Encinas C, Maruenda JI, Laguía M. Significant ventilatory functional restriction in adolescents with mild or moderate scoliosis during maximal exercise tolerance test. ***Spine*** 2005; 30 (14): 1610- 5.
4. Lenke LG, Bridwell KH, Baldus C, Blanke K. Analysis of pulmonary function and axis rotation in adolescent and young adult idiopathic scoliosis patients treated with Cotrel-Dubousset instrumentation. ***J Spinal Disord*** 1992; 5 (1): 16-25.
5. Pehrsson K, Bake B, Larsson S, Nachemson A. Lung function in adult idiopathic scoliosis: a 20 year follow up. ***Thorax*** 1991; 46 (7): 474- 8.
6. Jackson RP, Simmons EH, Stripinis D. Coronal and sagittal plane spinal deformities correlating with back pain and pulmonary function in adult idiopathic scoliosis. ***Spine*** 1989; 14 (12): 1391- 7.
7. Libby DM, Briscoe WA, Boyce B, Smith JP. Acute respiratory failure in scoliosis or kyphosis: prolonged survival and treatment. ***Am J Med*** 1982; 73 (4): 532- 8.
8. Smyth RJ, Chapman KR, Wright TA, Crawford JS, Rebuck AS. Pulmonary function in adolescents with mild idiopathic scoliosis. ***Thorax*** 1984; 39 (12): 901- 4.
9. Pehrsson K, Danielsson A, Nachemson A. Pulmonary function in adolescent idiopathic scoliosis: a 25 year follow up after surgery or start of brace treatment. ***Thorax*** 2001; 56 (5): 388- 93.
10. Vedantam R, Lenke LG, Bridwell KH, Haas J, Linville DA. A prospective evaluation of pulmonary function in patients with adolescent idiopathic scoliosis relative to the surgical approach used for spinal arthrodesis. ***Spine*** 2000; 25 (1): 82- 90.
11. Ordiales Fernández JJ, Fernández Moya A, López Fanjul JC, Colubí Colubí L, Nistal de Paz F, Rodrigo Sáez L. Study of pre and postsurgical ventilatory function in idiopathic thoracic scoliosis using the Harrington method. ***Rev Clin Esp*** 1998; 198 (6): 356- 9.
12. Lenke LG, Bridwell KH, Blanke K, Baldus C. Analysis of pulmonary function and chest cage dimension changes after thoracoplasty in idiopathic scoliosis. ***Spine*** 1995; 20 (12): 1343- 50.
13. Kinnear WJ, Johnston ID. Does Harrington instrumentation improve pulmonary function in adolescents with idiopathic scoliosis? A meta-analysis. ***Spine*** 1993; 18 (11): 1556- 9.
14. Lonner BS, Kondrachov D, Siddiqi F, Hayes V, Scharf C. Thoracoscopic spinal fusion compared with posterior spinal fusion for the treatment of thoracic adolescent idiopathic scoliosis. ***J Bone Joint Surg Am*** 2006; 88 (5): 1022- 34.
15. Kim YJ, Lenke LG, Bridwell KH, Kim KL, Steger-May K. Pulmonary function in adolescent idiopathic scoliosis relative to the surgical procedure. ***J Bone Joint Surg Am*** 2005; 87 (7): 1534- 41.
16. Faro FD, Marks MC, Newton PO, Blanke K, Lenke LG. Perioperative changes in pulmonary function after anterior scoliosis instrumentation: thoracoscopic versus open approaches. ***Spine*** 2005; 30 (9): 1058- 63.
17. Lenke LG, Newton PO, Marks MC, Blanke KM, Sides B, Kim YJ, Bridwell KH. Prospective pulmonary function comparison of open versus endoscopic anterior fusion combined with posterior fusion in adolescent idiopathic scoliosis. ***Spine*** 2004; 29 (18): 2055- 60.
18. Chen SH, Huang TJ, Lee YY, Hsu RW. Pulmonary function after thoracoplasty in adolescent idiopathic scoliosis. ***Clin Orthop Relat Res*** 2002; (399): 152- 61.
19. Gazioglu K, Goldstein L, Femi-Pearse D, Yu PN. Pulmonary function in idiopathic scoliosis. ***J Bone Joint Surg Am*** 1968; 50: 1391-9.
20. Westate HD, Moe JH. Pulmonary function in kyphoscoliosis before and after correction by the Harrington instrumentation method. ***J Bone Joint Surg Am*** 1969; 51(5): 935-46.
21. Makley JT, Herndon CH, Inkley S, Doershuk C, Matthews LW, Post RH, et al. Pulonary function in paralytic and non-paralytic scoliosis before and after treatment. A study of sixty-three cases. ***J Bone Joint Surg Am*** 1968; 50 (7): 1379- 90.
22. Gucker T: Changes in vital capacity in scoliosis: Preliminary report on effects of treatment 1962; ***J Bone Joint Surg Am*** 44A:469-481.