

Improved pulmonary function after concave rib resection and posterior instrumentation for idiopathic scoliosis

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The authors conducted a prospective study in order to evaluate the effect of concave rib osteotomy on pulmonary function, in the context of posterior instrumentation for the treatment of idiopathic scoliosis. Concave rib osteotomy improves the flexibility of the spine, especially in very rigid curves above 70°. Seventy-eight consecutive children with a Cobb angle above 70° were included in the study. Pulmonary function was measured preoperatively and at 12 months postoperatively. After surgery, all patients took part at an intense pulmonary rehabilitation program. The mean preoperative Cobb angle of 91.7° improved to an average of 29.5°. Unexpectedly, the postoperative pulmonary function, measured as an absolute value after one year, was significantly better than the preoperative pulmonary function. Very probably the concave rib osteotomy had allowed expansion of the thoracic cage. Most other studies about scoliosis surgery with disruption of the rib cage have reported a stabilized or a diminished pulmonary function. An exception might be the use of expansion thoracostomy with insertion of vertical expandable prosthetic titanium ribs in congenital scoliosis.

Keywords: adolescent idiopathic scoliosis ; concave rib osteotomy ; pulmonary function.

INTRODUCTION

Idiopathic scoliosis is a complex three-dimensional deformity of the vertebral column ; it accounts for 80 to 85% of all lateral spinal curva-

tures (16). Surgery is suggested when the curve exceeds 40° (13).

Anterior release is indicated for curves of 70° or more, prevention of crankshaft phenomenon and kyphotic deformities greater than 70° (1). The negative effects of anterior release on pulmonary function have been well documented in the literature (6,10,16).

Posterior release became possible via the concept of concave rib osteotomy, introduced by Flinckum in 1963 (5). Halsall *et al* tested flexibility of the spine in cadavers, before and after sectioning the

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ribs on the tension side, and found an average increase in deflection of 53% (7). Kostuik (9), Mann *et al* (14), and more recently El Masry *et al* (3) have reported the use of concave rib resection and its potential value as a release procedure, however without commenting upon the consequences for pulmonary function.

The current study focuses on the effect of concave rib resection on pulmonary function, in the context of posterior instrumentation and fusion.

MATERIALS AND METHODS

This prospective therapeutic study included 78 consecutive children who underwent posterior spinal instrumentation and fusion with iliac bone grafts, after concave rib osteotomy, for the correction of adolescent idiopathic scoliosis with a Cobb angle above 70°. There were 54 females and 24 males. The average age was 14.7 years (range 12–18 years). The mean height was 140 cm (range 110–170 cm). The mean weight was 46.4 kg (range 32–75 kg). The curves were classified according to the surgical classification system of adolescent idiopathic scoliosis described by Lenke *et al* (11) : 44 patients (57%) had a type 1 curve (main thoracic) ; 18 (23%) a type 2 curve (double thoracic), and 16 (20%) a type 3 curve (double major).

All patients had a posterior instrumented arthrodesis of the spine with hybrid Isola® instrumentation, using hooks, wires and screws (De Puy Acromed, Raynham, Mass, USA) and iliac bone grafts. All 78 patients had an additional modified concave rib osteotomy, according to the technique described by El Masry *et al* (3). An orthosis was not used postoperatively.

One week postoperatively a pulmonary rehabilitation program was started, based on breathing exercises, incentive spirometer, treadmill and cycle ergometer, 3 days a week. These exercises were followed, one month later, by abdominal weight resistant breathing exercises, until one year post surgery.

All patients underwent pulmonary function tests preoperatively and one year postoperatively. A computerized spirometer (Chest graph HI-701 Chest M.I. Inc.Hongo, Bunkyo-Ku-Tokyo, Japan)

was used. The tests were performed with the patient standing. Each measurement was repeated three times, and the highest reading was selected. Vital Capacity (VC), Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1) were determined. Only absolute values were considered. No attempt was made to compare the absolute values with predicted values.

Coronal and lateral radiographs of the spine were made on 91-cm-long cassettes with the patient standing. The Cobb angle was determined (2). All radiographic measurements were done by one of the authors (AMS), independently of the operative team.

RESULTS

Correction of scoliosis

The mean preoperative Cobb angle was 91.7° (range 70°-134°), the mean postoperative Cobb angle was 29.5° (range 11°-50°), a correction of 68%.

Pulmonary function

Taking each variable (VC, FVC, FEV1) consecutively, the appropriate statistical test was a matched-pairs *t*-test. Results are shown in table I : all three variables improved significantly after 2 years.

DISCUSSION

Vedantam *et al* (17) checked the effect of scoliosis fusion on pulmonary function, and concluded that, two years postoperatively, chest cage disruption caused a *status quo* in pulmonary function, while extra-thoracic surgery was correlated with an improvement. Similarly, Lenke (11) *et al* found a slightly diminished pulmonary function in 19 adolescents, 2 years after posterior fusion and thoracoplasty.

This study appears to be the first to evaluate the effect of concave rib osteotomy on pulmonary function in the context of scoliosis surgery. This technique improves the flexibility of the spine

Table I. — Pulmonary function, in absolute values, before and one year after concave rib osteotomy, combined with posterior scoliosis fusion and instrumentation

Variable	Number of patients	Mean preop.	Mean at 1 year	Mean difference	95% conf. limits for mean difference	p value
VC	78	3.23 l	3.45 l	0.22 l	(0.02-0.42)	0.032
FVC	78	2.81 l	3.00 l	0.19 l	(0.02-0.36)	0.028
FEV1	78	2.29 l	2.51 l	0.23 l	(0.07-0.39)	0.006

VC = Vital Capacity. FVC = Forced Vital Capacity. FEV1 = Forced Expiratory Volume in liters/second.

and is thus indicated for rigid curves above 70°. It achieves a good correction and avoids an anterior release which has been shown to improve the pulmonary function: one year postoperatively and after a pulmonary rehabilitation program, VC, FVC and FEV1 showed significant improvement. Most other studies about pulmonary function after scoliosis surgery mention at best a *status quo* of this function. An exception might be the use of expansion thoracostomy with insertion of vertical expandable prosthetic titanium ribs in congenital scoliosis (4).

REFERENCES

- Bridwell KH.** Surgical treatment of idiopathic adolescent scoliosis. *Spine* 1999 ; 24 : 2607– 2616.
- Cobb JR.** Outline for the study of scoliosis. *Instr Course Lect* 1948 ; 5 : 261–275.
- El Masry MA, Saleh AM, McWilliams AB et al.** Concave rib osteotomy : a modified technique revisited. *Eur Spine J* 2007 ; 16 : 1600-1603.
- Emans JB, Caubet JF, Ordonez CL, Lee EY, Ciarlo M.** The treatment of spine and chest wall deformities with fused ribs by expansion thoracostomy and insertion of vertical expandable prosthetic titanium rib : growth of thoracic spine and improvement of lung volumes. *Spine* 2005 ; 30 : S58-S68.
- Flinchum D.** Rib resection in the treatment of scoliosis. *South Med J* 1963 ; 56 : 1378-1380.
- Graham EJ, Lenke LG, Lowe TG et al.** Prospective pulmonary function evaluation following open thoracotomy for anterior spinal fusion in adolescent idiopathic scoliosis. *Spine* 2000 ; 25 : 2319-2325.
- Halsall AP, James DF, Kostuik JP, Fernie GR.** An experimental evaluation of spinal flexibility with respect to scoliosis surgery. *Spine* 1983 ; 8 : 482-488.
- 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* 2005 ; 87-A : 1534-1541.
- Kostuik JP.** Recent advances in the treatment of painful adult scoliosis. *Clin Orthop Relat Res* 1980 ; 147 : 238-252.
- Kumano K, Tsuyama N.** Pulmonary function before and after surgical correction of scoliosis. *J Bone Joint Surg* 1982 ; 64-A : 242-248.
- Lenke LG, Bridwell K, Blanke K, Baldus C.** Analysis of pulmonary function and chest cage dimension changes after thoracoplasty in idiopathic scoliosis. *Spine* 1995 ; 20 : 1343-1350.
- Lenke LG, Betz RR, Harms J.** Adolescent idiopathic scoliosis : a new classification to determine extent of spinal arthrodesis. *J Bone Joint Surg* 2001 ; 83-A : 1169-1181.
- Leroux MA, Zabjek K, Simard G et al.** A noninvasive anthropometric technique for measuring kyphosis and lordosis : an application for idiopathic scoliosis. *Spine* 2000 ; 25 : 1689-1694.
- Majd ME, Castro FP Jr, Holt RT.** Anterior fusion for idiopathic scoliosis. *Spine* 2000 ; 25 : 696-702.
- Mann DC, Nash CL Jr, Wilham MR, Brown RH.** Evaluation of the role of concave rib osteotomies in the correction of thoracic scoliosis. *Spine* 1989 ; 14 : 491-495.
- Masso PD, Gorton GE 3rd.** Quantifying changes in standing body segment alignment following spinal instrumentation and fusion in idiopathic scoliosis using an optoelectronic measurement system. *Spine* 2000 ; 25 : 457-462.
- 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 : 82-90.
- Weiner P, Man A, Weiner M et al.** The effect of incentive spirometry and inspiratory muscle training on pulmonary function after lung resection. *J Thorac Cardiovasc Surg* 1997 ; 113 : 552-557.