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CASE REPORT

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A physiological approach to surgical treatment of progressive early idiopathic scoliosis

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Abstract The results of previous clinical and experimental studies have provided accumulated evidence for the role of rib asymmetry in the pathogenesis of idiopathic scoliosis (IS). Moreover, it has been shown that scoliosis induced in rabbits can be corrected by elongation or growth stimulation of ribs on the side of the convexity. Taking these observations into consideration, a 7-year-old girl with right convex thoracolumbar IS was operated upon by 2-cm shortening of three concave ribs. The preoperative coronal Cobb angle was 46° and the sagittal angle was 55°. Twenty-seven months after the operation the curves were reduced to 21° and 35°, or by 54 and 36%, respectively. It is concluded that new, easy to perform and harmless interventions on the ribs may have vast implications for the overall treatment of young patients with early progressive, thoracic, IS.

Key words Early thoracic scoliosis · Treatment · Rib shortening

Introduction

The results of previous studies have shown that in girls with right convex thoracic adolescent idiopathic scoliosis (IS) there is significantly increased vascularity of the left breast as compared with the right one [10]. It has also been found that in deceased women with right convex thoracic IS, the mean length of the ribs corresponding to the apical and the two periapical vertebrae was greater on the concave than on the convex side [11]. These changes were ascribed to disturbed sympathetic function. Indeed, in growing rabbits stimulation of the longitudinal rib growth by unilateral resection of intercostal nerves, including the sympathetic fibres, resulted in hyperaemia of the denervated anterior hemithorax [1], increased longitudinal rib growth [2] and scoliosis with the convexity to the opposite side of the denervation and characteristics of IS in humans [3].

The inter-related results of these and other clinical and experimental studies have provided evidence supporting the thoracospinal theory of the pathogenesis of IS. According to this new theory, stimulation of longitudinal growth of the left ribs is the origin of right convex IS in adolescent girls [15].

In connection with these studies, experiments were also undertaken to investigate the possibility of correcting or suppressing the progression of scoliosis induced in rabbits.

In a first experiment, scoliosis was induced by unilateral resection of three intercostal nerves on the left side in growing rabbits. Three months after the operation, all rabbits had developed scoliosis with a mean Cobb angle of 22.5°. The concavity of the curve was on the side of the denervation. At this time, one rib of the convexity, one, two, three or four spaces above the apical vertebra of the curve, after osteotomy, was mechanically elongated by 7 mm using a metallic expander. The initial scoliosis was corrected immediately after the operation, and remained unchanged 3 weeks later [14] (Fig. 1).

In a second experiment, three intercostal nerves were resected on one side of the thorax in rabbits with a mean body weight of 350 g. Then the animals were allocated into three groups, with six rabbits in each. In the first group, used as reference, a progressive scoliosis developed in all animals, which 3 months after the operation averaged 27.0°. In the second group, group A, 1 month af-

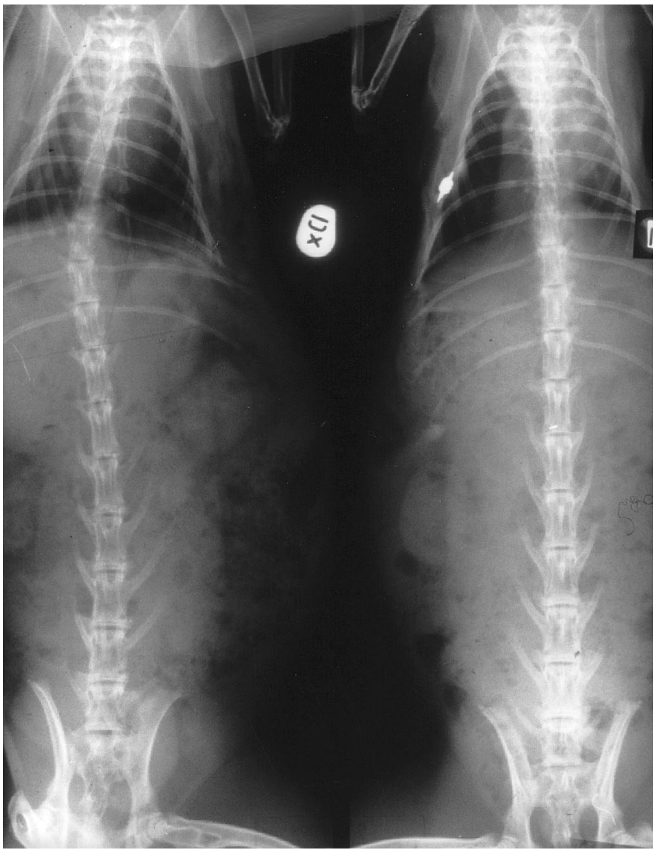


Fig. 1 Scoliosis induced in a growing rabbit 3 months after resection of three intercostal nerves on the right side *(left)*. The correction achieved immediately after elongation of one rib on the side of the convexity was unchanged 3 weeks after the rib elongation *(right)*

Table 1 Evolution of the degree of the frontal Cobb angle after growth stimulation of convex ribs in scoliotic rabbits (mean ± SD)

	Preoperative Cobb angle	Postoperative Cobb angle		
		1 month	2 months	3 months
Ref group	1.3 ± 0.5	10.5 ± 1.0	20.5 ± 1.4	27.0 ± 2.2
Group A	2.8 ± 2.3	15.2 ± 4.0[a]	11.3 ± 3.0	10.8 ± 1.5*
Group B	1.5 ± 0.6	12.8 ± 2.1	18.0 ± 1.7[a]	18.2 ± 1.7

* One versus 3 months $P < 0.05$
[a] Time of the second operation

ter the first operation, three intercostal nerves were resected on the side of the convexity. At this time the mean Cobb angle was 15.2°. Two months later the curve was reduced to 10.8° ($P < 0.05$). In the third group, group B, nerve resection on the convexity was performed 2 months after the first operation. The Cobb angle, which at that time was 18°, remained unchanged 1 month later (Table 1). The degree of thoracolumbar kyphosis and the cervicothoracic lordosis in the three groups of rabbits showed similar reduction [14].

The results of these two experiments indicate that in growing rabbits mechanical elongation of one rib at the side of the convexity efficiently corrects experimentally induced scoliosis, and that stimulation of the rib growth at the side of the convexity positively affects the progression of scoliosis. It was also shown that the outcome of stimulation of the rib growth depends on the age of the animal and the degree of deformity at the time of the operation.

Existing rib length asymmetry in scoliosis can be counteracted either by shortening or resecting a number of ribs on the concavity or by rib lengthening on the side of the convexity of the curve. The first of the three options was adopted for the first clinical trial.

Case report

A right convex thoracolumbar IS was diagnosed in October 1994 in a 6-year-old Chinese girl. The apex of the curve was at T10, the coronal T7–L2 Cobb angle was 30°; the sagittal T1–T12 Cobb angle was 55° (Fig. 2).

At the follow-up 1 year later, the coronal Cobb angle had increased to 46° (Fig. 3).

Consent was obtained from the girl's parents to shorten three ribs on the concavity of the curve. The operation was approved by the local health authorities.

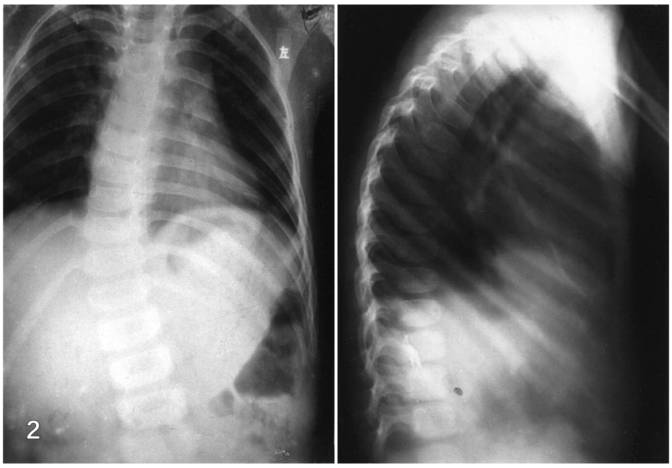
A posterolateral 8-cm-long skin incision was made along the lateral aspect of the erector spinae muscle on the concavity of the curve. Three ribs were dissected free from soft tissues and periosteum and were osteotomized with a saw just lateral of the costotransverse joint. An approximately 2-cm-long piece was removed from each rib and the fragments were approached and fixed with a silk suture. The wound was closed in layers. No thoracic drain was applied. The time of the operation was 50 min and the perioperative bleeding 40 ml. The procedure and the postoperative course were uneventful.

The girl was mobilized 2 days after the operation and she left the hospital, without brace or other support, after a further 8 days. The anteroposterior radiographs after the operaton showed that the shortened concave ribs were the 9th, 8th and 7th. Seventeen months after the operation the girl was in good general condition and had no complaints. Radiographic examination showed a coronal Cobb angle of 30°; the sagittal Cobb angle was 35° (Fig. 4). At the last follow-up, 27 months after the operation, the frontal Cobb angle was 21°; the sagittal Cobb angle was unchanged (Fig. 5).

Discussion

The aim of the operation in the reported case was to exert a double correcting effect on the curvature. On the one hand, shortening the concave ribs corresponding to the apical, the subjacent and the suprajacent vertebrae applied a lateral traction force on the spinal segment on the concavity. On the other, a pressure force in the same direction was brought into play by the unaffected longitudinal growth of the corresponding ribs of the convexity.

The outcome of the operation in this case shows that 27 months after the intervention, the preoperative coronal Cobb angle had decreased by 54 and the sagittal by 36%.



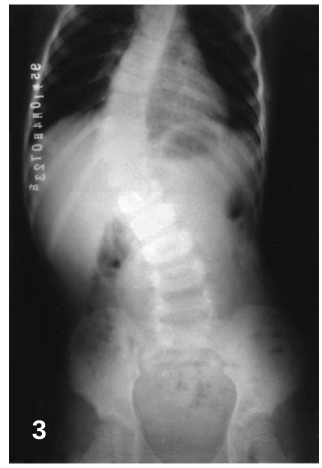
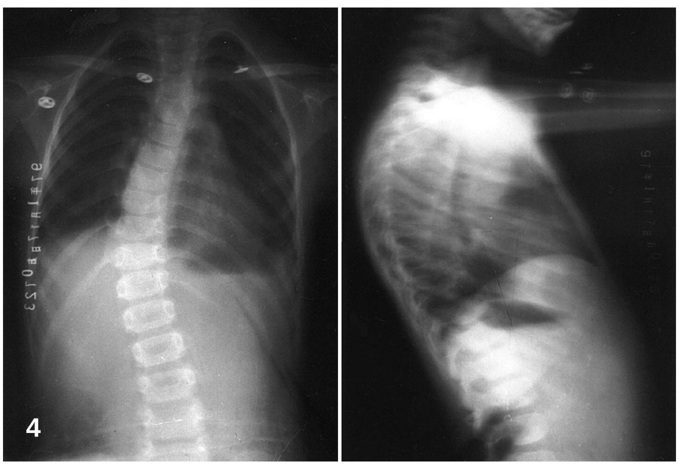


Fig. 2 Right convex thoraco-lumbar idiopathic scoliosis diagnosed in a 6-year-old girl. The coronal Cobb angle was 30° *(left)* and the sagittal Cobb angle 55° *(right)*

Fig. 3 One year later the curve had increased to 46°. At that time the girl was operated upon



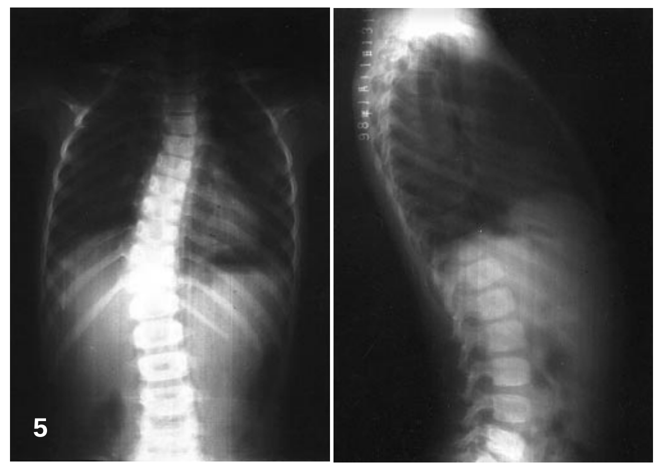


Fig. 4 Fifteen months after the operation the coronal Cobb angle was 30° *(left)* and the sagittal 35° *(right)*

Fig. 5 Twenty-seven months postoperatively the coronal Cobb angle was 21° *(left)*; the sagittal Cobb angle was unchanged *(right)*

These results, together with those of our previous experimental and clinical studies [15] introduce a new concept in the operative treatment of scoliosis, suggesting that operation on the ribs, based on established physiological principles, can efficiently correct the early progressive thoracospinal deformity in IS.

Rib resection or costodesis on the concavity or the convexity of scoliotic curves has previously been used by several authors either in isolation or in combination with other therapeutic measures [4, 8, 12, 13, 17]. However, the results of these clinical trials in patients of different age and with curves of varying aetiology, degree and pattern have been largely disappointing and the approaches consequently abandoned. More recently, resection of concave ribs has been advocated as a first stage of spinal surgery in scoliosis [12, 16].

On the other hand, it has been reported that resection of five transverse processes with a part of the corresponding ribs on the side of the concavity in a 16-year-old patient resulted in a decrease of the Cobb angle by 43% 2 months after the operation and was unchanged 2½ years later [18]. Moreover, in cases of scoliosis due to rib osteoblastoma [7] or fused ribs [5], resection of the affected ribs resulted almost in normalisation of the configuration of the spine.

It has also been reported that the progression of scoliosis induced in chickens by pinealectomy is suppressed after rib resection [6] or rib shortening [9] on the concavity of the curve and that in young chickens rib resection induces more severe scoliosis than rib transection [6]. In these clinical as well as experimental reports, rib resection was carried out in order to mechanically influence the configuration of the scoliotic spine. There is no report of successful regression of early curves in scoliotic patients by shortening of concave ribs intended to restore the disturbed equilibrium of forces affecting the spine.

The unintensional shortening of the three ribs above the apical segment of the curve indicates further that the realignment of the plastic spine of the young child does not depend on the level of the rib shortening. This observation is in accordance with the results of the experimental study referred to above.

It is obvious that no conclusions can be drawn from these preliminary results of a single case regarding the effectiveness of a new operative procedure, since the thoracospinal deformity in this, now 10-year-old, girl may further decrease or possibly relapse, and it may even be converted.

However, the results of this case indicate that surgical intervention to restore the disturbed balance of forces affecting the scoliotic spine, based on physiological concepts and supported by substantial experimental and clinical evidence, has good prospects of a successful outcome. Therefore, studies are currently in progress to define the indications and technical details and to evaluate the results of different types of operation on the ribs.

In view of such perspectives, it is legitimate to speculate on the vast implications new, easy-to-perform and harmless operations based on physiological principles may have for the overall treatment of juvenile or early adolescent patients with moderate progressive curves of thoracic IS. This is particularly hopeful taking into consideration the options of treatment we have today, i.e. bracing for several years with dubious results and, as a final resort, not always risk free major surgery with severe effects on the mobility of the spine. The psychological reactions of the child to these options should not be underestimated, either.

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