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Surgery of chest wall deformities[1]

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Abstract

Objective: To evaluate the medium-term results of 77 surgical corrections in patients with chest wall deformities, 53 (68.8%) with pectus excavatum and 24 with pectus carinatum, operated upon from 1985 to 1994. **Methods:** The mean age of the patients was 14.7 years (4–39 years) and 77% were younger than 15 years of age. There were 59 male (76.7%) and 18 female patients. Only four had a family history of the malformation. Seven patients (9.1%) presented with asthma-like symptoms, and 13 (16.9%) referred dyspnea and tiredness for small efforts. The remainder (74.2%) were asymptomatic, but most were psychologically disturbed by the deformity and postural abnormality. Two patients had other skeletal abnormalities. The modified surgical technique used in all cases consisted of subperichondrial resection of the abnormal costal cartilages, transverse and longitudinal osteotomies of the sternum and internal stabilization with a steel rod which was generally removed between 6 and 12 months postoperatively. **Results:** There was neither early nor late mortality. One patient had a pneumothorax which required chest tube drainage. The mean admission time was 10.5 days (8–14 days). Follow-up was complete, and 90% of the patients had increased effort tolerance. Five of the seven patients (72%) with 'asthmatic' symptoms showed a decrease in the frequency of the crises. Two patients had recurrence of the depression by 3 and 8 months, respectively. The remaining 75 patients (97.3%) were satisfied with the cosmetic result of the surgery. **Conclusions:** Surgical treatment of chest wall deformities using this technique leads to good cosmetic, orthopedic and psychological results. We believe that the operations should be performed at any age in patients who have at least a moderate deformity. © 1997 Elsevier Science B.V.

Keywords: Chest wall; Chest wall deformities; Pectus carinatum; Pectus excavatum; Surgery

1. Introduction

Pectus excavatum and pectus carinatum are relatively rare chest wall deformities, with a reported incidence of 0.01–0.1%. These deformities are disturbing for many children and young adults and their cosmetic impact on a child's evolving personality may have lasting consequences. On the other hand, the poor posture, characterized by slumping shoulders and protuberant abdomen, may cause orthopedic problems in adulthood [10].

Many techniques for correction of these deformities have been advanced during the eight decades since the first repairs performed by Meyer in 1911 [16], but it was Ravitch who, in 1949 [19] and in 1965 [20], advocated complete excision of the anomalous cartilages, posterior sternal osteotomy and internal fixation of the sternum for which he interposed a wedge of bone in the posterior table [20]. Subsequently, several modifications of these basic techniques have been designed to maintain the corrected position of the sternum.

The basic features of the surgical repair used in our series of patients are similar to those advocated by Welch [24] and Haller and associates [10] with preservation of the perichondrium, transverse anterior wedge osteotomy with internal substernal support. In some patients we complemented the sternal repair with a

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longitudinal osteotomy. The objective of this report is to evaluate the medium-term results of surgical correction in 77 patients with chest wall deformities, 53 with pectus excavatum and 24 with pectus carinatum, operated over a 10-year period.

2. Patients and methods

2.1. Clinical data

The medical records of all patients who underwent surgical correction of pectus deformities in our Institution, from 1985 through 1994, were reviewed retrospectively.

There were 59 male (76.7%) and 18 female patients. The deformity in these patients was first noted by the parents, the general practitioner or the pediatrician before the age of 7 years in 90% of the cases and in 60% it was present at 2 years of age. The mean age at the time of repair was 14.7 years (4–39 years) and three-quarters were younger than 15 years of age (Table 1). Fifty-three patients (68.8%) had pectus excavatum and 24 (31.2%) had pectus carinatum. A family history of the malformation was present in only four (5.2%) cases. Seven patients (9%) reported asthma-like symptoms, and 13 (16.8%) referred dyspnea and tiredness for small efforts. The remainder (74.2%) were asymptomatic, but most were psychologically disturbed by the deformity and postural abnormality which resulted from mild to moderate thoracic spine scoliosis. There were no differences of symptoms with regard to age and/or sex.

Eight patients (10.4%) had associated congenital cardiac malformations: four had pulmonary stenosis, six had atrial septal defect, one had ventricular septal defect, and one had mitral valve regurgitation. Thirty-five patients (45.5%) had scoliosis of the spine and two had other skeletal abnormalities. Ten patients (14.4%) had ECG changes constituted by right axis deviation or incomplete right bundle branch block. Finally, 17 patients (22.1%) had abnormal respiratory function tests with mild to moderate decrease of the values of the vital capacity and forced expiratory volume at 1 s (FEV_1). In all patients the chest X-ray demonstrated the typical alteration of the postero-anterior diameter of the thorax and, in the cases of pectus excavatum, the leftward and posterior deviation of the heart, covering the hilum of the left lung. The sternal roentnogram showed either the concavity or anterior protrusion of the body of the sternum (Fig. 1). The severity of the pectus deformity was graded by measuring the distance between the sternum and the spine in the chest X-rays. The pectus excavatum deformities were classified, according to Chin [5], in type I—16 patients (30.1%), type II—16 patients (30.1%), and type III—21 patients (39.8%).

2.2. Surgical technique

The surgical technique was identical in all cases, adapted to each of the two types of deformity, and included the following essential steps (Figs. 2 and 3):

(1) Longitudinal skin incision between the upper limit of the deformity and the xiphoid. Two patients had a submammary incision.

(2) Dissection of both pectoral muscles from their attachments to the sternum and costal cartilages with electrocautery and lateral retraction beyond the chondrocostal junction. Longitudinally, the dissection extended from the second intercostal space to the seventh rib.

(3) Detachment of the rectus muscles from the sternum, xiphoid and costal cartilages. Occasionally, the xiphoid was excised.

(4) Blunt dissection of the substernal space with a finger.

(5) Incision of the perichondrium in the mid-anterior surface of abnormal costal cartilages bilaterally, extending from the costochondral junction to the sternum.

(6) Enucleation of the abnormal costal cartilages (4–6 pairs), preserving the perichondrium, after dissection of the lateral and posterior surfaces.

(7) Transverse anterior wedge osteotomy of the sternum, at the level of the lowest normal rib, without involvement of the posterior table to maintain adequate blood supply. In this way, good antero-posterior mobility of the sternum was obtained.

(8) Longitudinal wedge osteotomy in the cases where there was lateral rotation of the sternum.

(9) Internal stabilization with a modified Steinmann pin (sharp ends cut and a 3 mm hole drilled in each extremity) placed behind the lower sternum and fixed laterally, with an absorbable suture, to the fifth or sixth ribs.

(10) Drainage of the pre-sternal space by two fine vacuum drains.

(11) Suture of the pectoral, rectus and intercostal muscles and perichondrium, on either side, over the sternum.

(12) Closure of the skin with a subcuticular absorbable suture.

Table 1
Age of patients at the time of repair

Age range (years)	No. of patients	(%)
4–10	14	18
10–15	45	59
15–20	11	14
20–40	7	9
Total	77	100

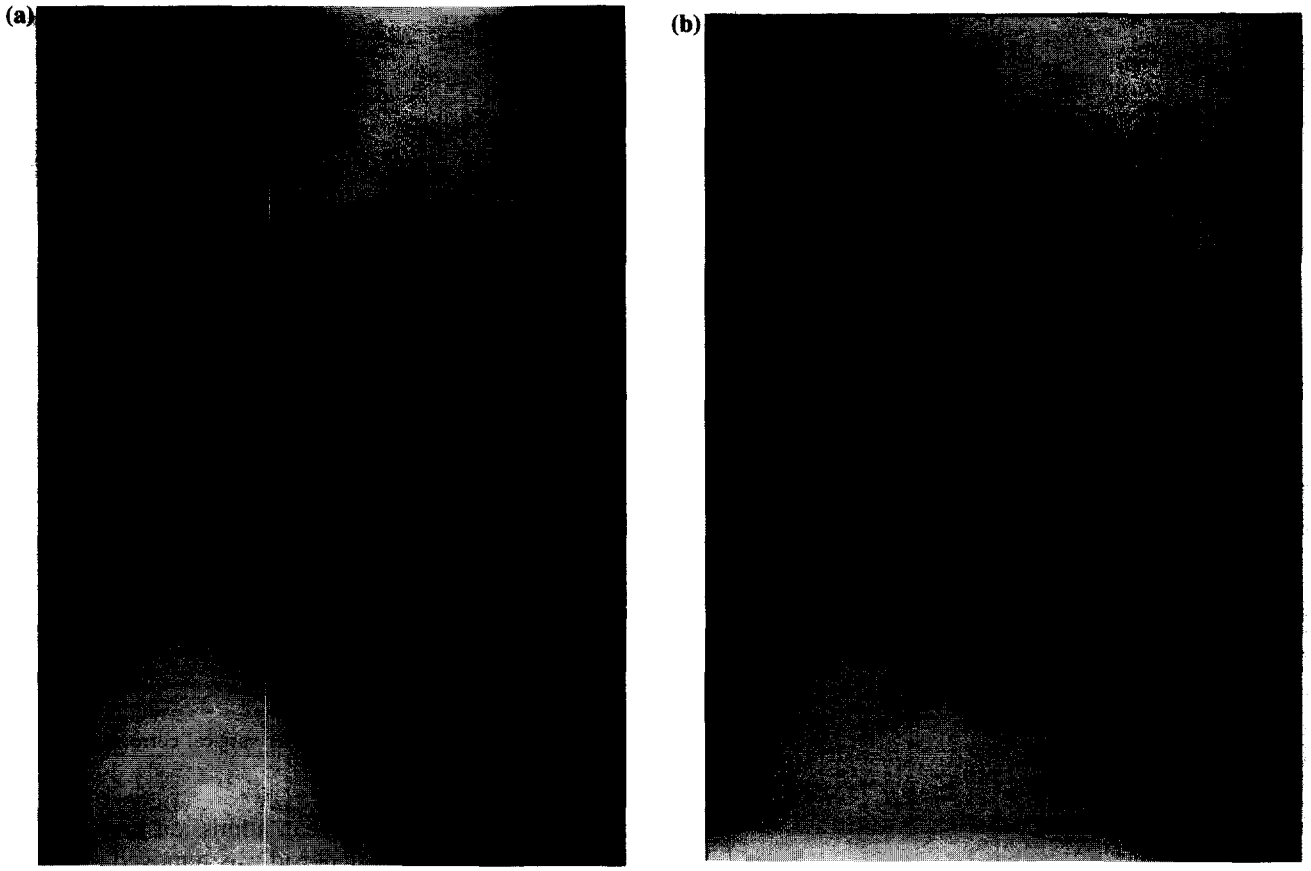

Fig. 1. Chest X-ray (lateral view) of: (A) patient with pectus carinatum; (B) patient with pectus excavatum.

(13) Removal of the drains within 96 h of the operation.

(14) Removal of the steel rod, 6–12 months after surgery, under local anesthetic, in patients in whom it was justified.

All patients but one were extubated after operation, on the operation table. Epidural analgesia was used for 24 h in all patients, which permitted physiotherapy after 12 h. Intravenous antibiotic therapy was instituted for 4 days, followed by oral antibiotics for another 4 days. Full physical activity was resumed by 2–3 months.

2.3. Follow-up

All patients were seen at the Outpatients Department, 2 weeks, 3 months and 6 months after surgery and at yearly intervals thereafter. The mean follow-up period ranged from 1 to 10 years (mean 4.8 years) and 62 patients (80.5%) were followed for more than 3 years. The assessment was made by physical examination (aspect, asymmetry of residual deformities, surgical scar) and radiological evaluation (chest X-ray) (Fig. 4). Patients were interrogated as to their subjective evaluation of the outcome, both from the cosmetic, psychological and symptomatic (cardiorespiratory) points of view. Similarly, the surgeon attempted to make an unbiased assessment of the result. The assessment for classification was a continuous one, to the date of the last visit.

The results were graded into one of four groups, according to Humphreys and Jaretzki [12]: excellent, good, fair and poor. An excellent result was considered if the anterior chest wall was restored to a normal or near normal configuration, the aspect of the surgical scar was good and the expectations of the patient and family were fully fulfilled. When there was some residual or recurrent sternal depression, the scar was good and the patient and family were satisfied, the result was considered good. If a mild degree of deformity remained or recurred and the patients were not fully satisfied with the final result, they were included in the fair group. In the cases when a second operation was done or considered indicated, the result was termed poor. Excellent and good results were considered 'satisfactory' and fair and poor results were considered 'unsatisfactory'.

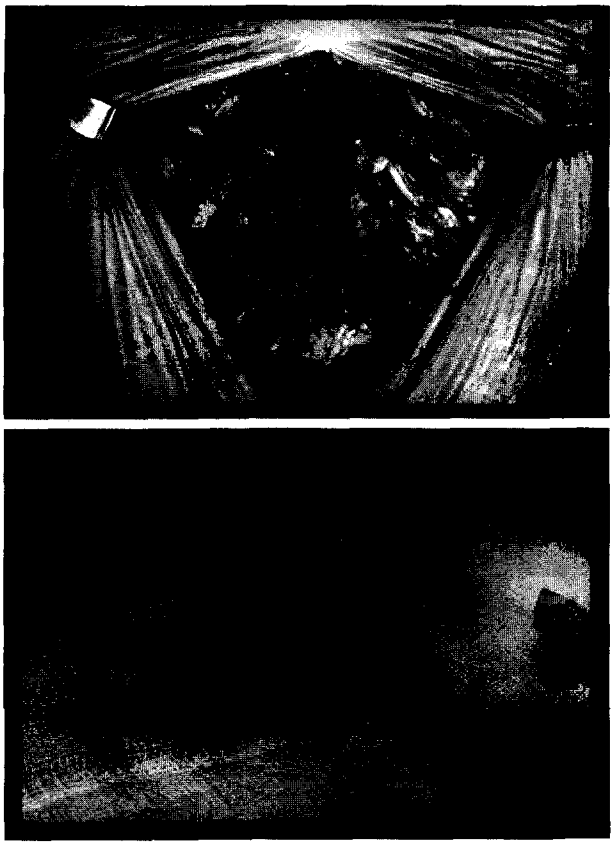

Fig. 2. (A) Photograph of the operative field after transverse and subperichondrial excision of the third to sixth costal cartilages; (B) pieces of abnormal cartilage removed during the procedure.

3. Results

The early and late results are resumed in Table 2. There was neither early nor late mortality. One patient required short-term ventilation (< 12 h) in the ward for mild respiratory insufficiency. One patient had a pneumothorax which required chest tube drainage and four patients had superficial wound infection because of a seroma, which was treated by partial separation of the edges of the wound. The mean admission time was 10.5 days (8–14 days). The steel rod was removed at a mean of 8.8 months (2–23 months) after surgery in 21 patients (27.3%).

Fig. 3. Same as in Fig. 2A, after positioning and fixation of the modified Steinmann pin.

Fig. 4. Final X-ray (lateral view) after surgical correction of pectus excavatum.

Follow-up was completed for all patients and 69 (90%) referred improved effort tolerance. Five of the seven patients with 'asthmatic' symptoms referred a decrease in the frequency of the crises. Two patients operated on for pectus excavatum (3.8%) had recurrence of the depression by 3 and 8 months, respectively. In these patients the steel rod had been removed 2 and 6 months post-operatively, respectively, because of detachment from the ribs resulting from breakage of the fixation sutures. None was reoperated.

Table 2
Results of repair in 77 patients with pectus excavatum and/or carinatum

	n	%
Early results		
Mortality	0	0
Morbidity		
Pneumothorax	1	1.3
Wound dehiscence/infection	4	5.2
Dislocation of Steinman pin	2	2.6
Mean (range) hospital stay (days)	10.5 (8–14)	
Late results		
Excellent	42	54.6
Good	33	42.8
Fair/poor	2	2.6

Subjectively, 75 patients (97.3%) were satisfied with the final result. Objectively, 42 (54.6%) of them were graded as excellent and 33 (42.8%) as good. Two patients (2.6%) had a poor result, as discussed above. No correlation could be found between the age at surgery and the results obtained. Functional respiratory tests were performed only on a few patients and no conclusions could be derived from those.

4. Discussion

Chest wall deformities are relatively rare during childhood with a reported incidence of up to 0.1%, variable from author to author. We have observed a predominance of pectus excavatum of 2.2:1, but other investigators have reported ratios varying from 9:1 to 2:1 [6]. The incidence was 3 times as high in male patients as in female patients (3.3:1), but we found no significant differences, with regard to symptoms, between sexes. The majority of the patients are asymptomatic but, occasionally, effort intolerance and dyspnea occur during adolescence.

Our policy has been to operate on patients with at least a moderate deformity, for cosmetic and psychological reasons (patients from the seaside required it more frequently!) and, occasionally, for cardio-respiratory complications resulting from mechanical compression by the depressed chest wall.

Different opinions have been expressed about the optimum age for surgery. Most advocate early operation [2,7,9,13,17,24], in contrast to others who prefer to operate after completion of growth because recurrence would be less common [21]. In our experience, the age of patients was not determinant of the results. Rather, the outcome appears to depend more on the anatomy and the condition at the time of surgery. Nonetheless, we believe that the optimal age for operation is between 5 and 10 years, although our data does not permit the advantage of early operation to be proved, possibly because the mean age of our patients at operation was 14.7 years, reflecting the late referral.

Although pectus excavatum was first described by Hippocrates who, in 1849, called it anterior scoliosis, it was not until 60 years ago that Ochsner and De Bakey [18] established the first principles for surgical correction of this deformity. In 1939, Brown [4] recommended correction by external traction of the sternum. Meanwhile, the phrenoplasty operation [3] and cosmetic operations by subcutaneous implantation of a silastic prosthesis in the area of the defect [15,22] were attempted but soon abandoned because of poor results, essentially because no correction of the skeletal abnormalities was made. Additionally, late complications with the silastic prosthesis were frequently observed.

By contrast, eversion operations with sternal turnover, as suggested by Judet and Valentin [13], do correct the anatomic deformity of the sternum. Wada et al. [23] described excellent results with this technique. However, the global experience has been limited and considerable concern has been expressed regarding the decreased potential for chest wall growth, and because of the possibility of infection and necrosis after reimplantation of the large devascularized bone graft [11].

Almost everybody now believes that overgrowth of the cartilages pushes the sternum down and causes the pectus excavatum, or pushes the sternum up and causes the pectus carinatum [19,20]. The deformed cartilages are thus the culprit in both types of lesion and for this reason should be removed. This was originally suggested by Lester, in 1946 [14], and Ravitch, in 1949 [19], who recommended complete excision including the perichondrium, and total separation of the intercostal muscles and of the xiphoid bone, in order to completely free the sternum. Later, in 1965, Ravitch [20] advocated a transverse posterior osteotomy of the sternum and interposition of a wedge of bone which, together with internal fixation by overlapping of the beveled ends of the second cartilages, helped to elevate the lower part of the sternum. By contrast, Welch [24], in 1958, had suggested preservation of the perichondrium and intercostal muscles and sternal osteotomy but without stabilization.

The modified technique we currently use is the sum of several steps of the techniques used by others, always having simplicity as a goal, but is significantly different from the Ravitch technique. To correct the depression or the elevation of the sternum, we make one (sometimes two) anterior transversal wedge osteotomy, through the complete thickness of the anterior sternal table. In the cases of rotation of the sternum because of an asymmetrical deformity, we find it necessary to complement the repair with a longitudinal wedge osteotomy of the anterior table. To our knowledge, this step has not been advocated by others.

To avoid recurrence of the sternal depression after the repair, most surgeons currently favor some method of postoperative sternal fixation [1,8,19]. Several methods of internal stabilization have been proposed and include support by autologous costal tissues, such as in the Ravitch technique, or pre-, trans- or retrosternal fixation with Kirschner wires. We have been using Steinmann pins modified in our hospital as described above, placed behind the sternum in an over-corrected position and attached laterally to the ribs with an absorbable suture. In the two earlier patients in our series who had recurrence of the depression, the steel rod had to be removed early because of detachment from the ribs, but we have subsequently modified the method of fixation and this complication was not observed again. We believe that the return to steel bars for

internal fixation of the sternum is a simpler step when compared to the use of bone grafts.

As to the results obtained in this series, the psychological and cosmetic complaints were changed in a positive way in most instances. Parallel to this, the physical condition of many patients has subjectively improved. Five of the seven patients with asthmatic symptoms showed a decrease in the frequency of the crises. Additionally, we also believe that surgery has an important prophylactic role, as it contributes to avoid or correct postural deformities which could eventually lead to severe scoliosis. We have used physiotherapy as an important adjuvant of surgery. It helps develop not only the pectoral muscles, thus helping to mask the deformity, but also the latissimus dorsi, the trapezius and the abdominal muscles, thus improving the posture and the scoliosis.

In conclusion, this retrospective clinical study makes us believe that surgical treatment of anterior chest wall deformities using this simplified technique leads to excellent cosmetic, orthopedic and psychological results. The age of the patient does not appear to be a determinant of the results. Hence, the operation should be performed in patients who have at least a moderate deformity.

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