Repair of pectus deformities: experience and outcome in 317 cases

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BACKGROUND: The most common congenital chest wall deformities are pectus excavatum and pectus carinatum. Various techniques have been described for correction of pectus deformities. We describe our experience with surgical repair of pectus deformity (PD) in adults, including our new technique, which uses a resorbable plaque for fixation of the sternum.

METHODS: We reviewed the records of 317 patients who underwent surgical correction of PD between October 1997 and December 2005.

RESULTS: All of the patients were male and the median age was 21.3 years (range, 16-32 years). Of 317 patients, the type of deformity was a pectus excavatum in 230 patients and a pectus carinatum in 87 of the patients. Four different operative techniques were used.There were no intraoperative deaths or major perioperative morbidity. The complications rate was 17%. Overall mean hospital stay was 14.25 days. In 208 patients who underwent a mid-term outpatient follow up (mean, 8 months), there was no recurrence. Patient satisfaction was excellent in 234 patients, good in 79 patients and fair in 4 patients.

CONCLUSION: The majority of patients with pectus deformity had been operated on during childhood; therefore there is limited published information about the correction of pectus excavatum and pectus carinatum deformities in adults. The most important point in pectus correction is to achieve proper and long-term stability of the sternum following osteotomy. Various techniques can be used for this purpose.

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The most common congenital chest wall deformities are pectus excavatum and pectus carinatum, which occur in approximately 1:400 and 1:1500 births, retrospectively.[1] Most of those deformities present at an early age and generally will manifest during adolescence. Surgical correction is often necessary for moderate or severe deformities.[2,3] Various techniques have been described for correction of pectus deformity (PD). For the last half-century the standard surgical approach to pectus repair has been based on techniques described by Ravitch.[4]

Most studies have described the repair of PD in children, with only a few reports in adults.[2,3,4] During the last seven years we have used a new technique, which was previously reported, for correction of PD in adults.[5] The aim of this study was to review our experience, including use of the new technique, with surgical repair of PD in adults. We believe that the data of this large series regarding the efficacy and safety of our new technique will be useful for comparison with others.

Methods

Our study was a retrospective review of the records of 317 patients with PD who underwent a surgical correction between October 1997 and December 2005. Patient medical records were reviewed for age, gender, symptoms, and family history, type of deformity, type of surgical correction, hospitalization time and postoperative morbidity. A conventional chest x-ray, pulmonary function tests and electrocardiogram were routinely performed for all patients before surgical correction. Recently computed tomography of the chest was performed to evaluate the severity of deformity in some patients. If the patients had a severe deformity, a non-invasive cardiac evaluation (echo cardiogram) was also performed. We used different surgical techniques based on the modified Rawitch technique for correction of PD.

Patients were divided in to four groups by operative technique: in the first group (n=89), a modified Rawitch technique (MRT) with a Kirschner wire; in the second group (n=53), a modified Rawitch technique + Kirschner wire + implantation of autoloque costal cartilages; in the third group (n=127), a modified Rawitch technique + resorbable plaque technique; and in the fourth group (n=48), a modified Rawitch technique + titanium plaque technique. The details of operative techniques were as follows: a midsternal incision was placed. Pectoral muscle flaps were mobilized. All of the involved cartilages were exposed and subperichondrial resection of the costal cartilages was carried out. The attachment of the rectus muscle to sternum was divided with an electrocautery. The sternum was dissected bluntly from the pericardium and pleura. Required intercostals bundles were completely divided from the sternum with the electrocautery, with the line of division being medial to the internal mammary arteries. One or two anterior horizontal osteotomies were performed depending on the type of deformity. The cartilaginous or osseous wedge fragment was placed into the osteotomy line in the pectus carinatum deformity. This part of the operation was almost the same as the classic Rawitch technique.

After these steps, we used four different techniques for fixation of the sternum: for the first group, the modified Rawitch technique with Kirschner wire (retrosternal support); for the second group, the modified Rawitch technique + Kirschner wire + implantation of autologue costal cartilages; for the third group, modified Rawitch technique + resorbable plaque technique + implantation of autoloque costal cartilages; for the fourth group, the modified Rawitch technique + titanium plaque technique + implantation of autologue costal cartilages. After the anterior wedge osteotomy and correction of the sternal defect, placement of two polyglactin absorbable sutures was placed over the osteotomy line for fixation. A Kirschner wire was used for sternal support and was removed at 21st postoperative day, in first group of patients. In second group of patients, the removed costal cartilages were re-shaped and these autologue cartilages grafts were placed into the perichondrial bed. All the other steps were the same as in the first group. In third group of patients, after the osteotomy was carried out, the position of the sternum was corrected and then an absorbable copolymer plaque was placed over the sternum on the line of the osteotomy (Figure 1). Fixation was established with absorbable polymer screws (Figure 2). The plaque and screws are available in different lengths, widths and thicknesses. With this technique, neither a metallic support nor non-absorbable sutures were used after osteotomy. A titanium plaque was used in fourth group instead of copolymer plaque. The placement of autologue cartilages grafts into the perichondrial bed was also carried out in groups III and IV.

The closing steps were the same for all groups. The beds of removed costal cartilages were reattached to the corrected sternum on both sides. A single chest tube was placed if the pleura had been opened and a hemovac drain was inserted across the sternum. The pectoral muscles and subcutaneous tissues were re-approximated and a subcuticular skin closure was performed.

Results

All of the patients were men and the median age was 21.3 years (range, 16 to 32 years). The most common preoperative symptom was exercise intolerance in 15 patients (4.73%), dyspnea on exertion in 9 patients (2.83%), and palpitation in 5 patients (1.57%). We found no major abnormalities in preoperative EKG in any patient. Therefore psychosocial discomfort is the main indication for operation in our patients. Of the 317 patients who underwent surgery to correct a PD, Pectus excavatum was present in 230 patients (72.55%) and pectus carinatum in 87 patients (27.45%). The type of pectus carinatum was the chondrogladiolar type in 54 patients and the chondromanubrial type in 33 patients. There were 89 (28.07%) patients in group 1, 53 (16.71%) in group 2, 127 (40.06%) in group 3 and 48 (15.14%) in group 4. There were no intraoperative deaths or major perioperative morbidity.

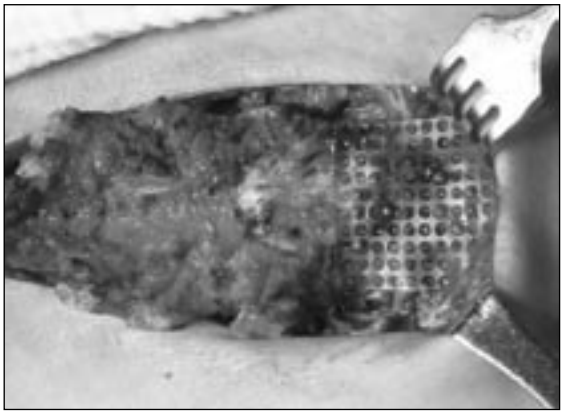

Figure 1. Implantation of the resorbable plaque on the corrected sternum.

Figure 2. Fixation of the resorbable plaque on the sternum with resorbable screws.

Complications occurred in 54 patients (17.03%), including seroma in 35 patients (11.04%), pneumothorax in 14 patients (4.41%), and skin incision infection in 5 patients (1.57%). The overall mean hospital stay was 14.25 days (range, 5 to 27 days). Mean hospital stays were statistically meaningful in groups 3 and 4 (4 and 4.3 days, respectively). In 208 (65.61%) who underwent a mid-term follow-up examination as outpatients (mean 8 months; range 4 months to 2 years), there was no recurrence. Patient satisfaction was excellent in 234 (73.81%) patients, good in 79 patients (24.92%) and fair in 4 patients (1.26%).

Discussion

Pectus excavatum is the most common congenital chest wall deformity, occurring approximately 1 in every 400 births.[1] Although PD is a congenital deformity, the depression in the chest becomes much more severe during the period of rapid skeletal growth in the early adolescence period and pectus excavatum and pectus carinatum deformities are often unrecognized until adolescent skeletal growth occurs. The timing and indications for surgery remain controversial.[6]

The majority of patients with PD have been operated on during childhood; therefore, there is limited published information about the correction of pectus excavatum and pectus carinatum deformities in adults.[2,3,7] Our center is a military medical academy and thus the majority of our patients are young males. Most of them were unable to find an opportunity for correction of their deformities in their civilian life because of social or economic reasons. Our institute has thus gained considerable experience with the correction of PD in adults during the last ten years.

A preoperative and postoperative assessment can be made using a simple chest x-ray. Some authors have mentioned radiological measurements, constructing a variety of indices and ratios based on the relationships of distance between the surface of the sternum and the anterior surface of the vertebral bodies to the total antero-posterior or transverse diameter of the chest such as the Welch index, the cardiothoracic index or chest index.[1] Ravitch proposed a method to bring the depression in sharp radiological relief in the lateral view. A stripe of barium paste is applied to the anterior midline and a lateral chest x-ray is taken. The x-ray film shows that there is a substantial distance between the skin and the depth of the funnel. This space is occupied by fat so that the deformity is, in fact, deeper than it appears.[8] Therefore, it is more realistic to use some standard measurements on the chest x-ray. Certainly, the main effect of a pectus repair operation on the anatomy of the chest cavity is an antero-posterior effect rather than a transverse effect.[9,10,11,12] Because of this, one can expect that the lateral chest x-ray measurements will be more valuable than posterior-anterior x-ray.

In our previous study, we used parameters measured on a posterior-anterior/lateral chest x-ray in patients with both pectus excavatum and PC. The parameters, which are measured on a posterior-anterior chest x-ray for both the pectus excavatum and pectus carinatum groups, were not statistically valuable, but on the lateral chest x-ray, three parameters had statistical value. Those were the lateral dimension of the cardiac silhouette, the distance between the most prominent and the recessed point of the

sternum and the anterior edge of the vertebral body and the lateral transverse dimension of the chest.[13]

There is a considerable difference between the preoperative and postoperative measurements of the lateral transverse dimension of the chest and the sterno-vertebral distance. But the interesting point is that, the pectus repair operation also has a certain effect on the lateral dimension of the cardiac silhouette. In severe and some moderate deformities, the heart is partially imprisoned in the left hemithorax, lifting it with each beat of the heart. This condition usually disappears after operative correction. We can explain the considerable increase in the lateral dimension of the cardiac silhouette after operation, by this mechanism.[6]

There is no consensus about the cardiopulmonary impairment that occurs with pectus deformities and how much improvement results after surgical repair.[3,14] Therefore, the decision to operate was based on largely psychological reasons as well as the severity of PD as noted on physical examination.

Although various techniques have been described up to now, some modifications of Rawitch's technique have been widely accepted. This technique is based on a subperichondrial resection of the deformed costal cartilages, sternal osteotomy and sternal fixation using a retrosternal support or other fixation modalities. Sternal turnover, a minimally invasive procedure, an anterior fixation of the sternum or reconstruction using implants is the other technique.[1,15]

The most important point in pectus correction is to achieve a proper and long-term stability of the sternum following osteotomy. There are plenty of recent series in the literature about the use of Kirschner wires or a plain strut for substernal support. It is usually necessary to perform a second operation for removing struts and some severe complications have been reported due to those supports. Onursal et al reported a case that underwent a severe operation because of a half broken steel strut embedded in the myocardium, 4 years after a pectus correction operation.[16] Stefani et al also reported another case involving migration of the metal support into the abdomen.[17] Some surgeons still prefer to use steel struts, as they are cheap, easy to find, and easy to place and extract, but such rare but severe complications should be keep in mind.

Fonkalsrud et al reported on the repair of PD in a large series of adults. They used a stainless steel bar for retrosternal support, which was removed six months after initial operation under light general anesthesia. The mean hospital stay was 3 days in their series. The sternal bar dislodged in three patients within 4 months and caused a pneumothorax in one patient.[3]

Recent publications have advocated a minimally invasive approach for repair of PD. Davis and Weinstein reported the results of 69 patients who underwent operation by Rawitch's method and compared their result with the Nuss procedure. They emphasize that the Ravitch procedure yields excellent results, low morbidity, low cost and a short hospital stay (2.9 days).[18,19,20] Our postoperative hospital stays were 6 and 7 days, respectively, in groups 3 and 4. But it is not necessary to perform a second operation for removal of supporting materials in those groups.

The complications in Davis and Weinstein's series were wound infection (1.4%) and seroma (7.2%). Seromas were seen in large adolescents in this series. They emphasize that seromas were related to larger flaps that attend the smaller skin incision. They propose to leave the Jackson-Pratt drains until drainage fully ceases.[4] Our most common complication also was seroma. We also believe that seromas can be easily managed by effective maintenance of drainage.

In a comparative study, Fonkalsrud and colleagues noted that patients undergoing minimally invasive pectus excavatum repair (average age 12 years old) or modified Ravitch repair (average age 17 years old) had excellent clinical results. Patients undergoing a modified Ravitch repair had longer operating times, but decreased hospital stay, complications rates, and use of pain medications.[3]

Popularization of the Nuss procedure has revolutionized the care of children with pectus deformity. This repair avoids cartilage resection and sternal osteotomy. In a large series from Nuss and colleagues, 257 (84.5%) patients had excellent initial results with minimal morbidity and no mortality; the mean age of these patients was 12.4 years. When comparing the results in younger patients with older patients, the authors noted that in the latter group, recovery time was longer, frequently requiring two bars for complete correction, and bar displacement was more common.[20] We believe that a larger cohort of patients with longer follow-up is necessary before widespread use of minimally invasive repair of PD in adult patients can be advocated.

Minimizing injury to the perichondrial sheaths during removal of cartilage segments is considered essential to permit maximum cartilage regeneration. Placing finely minced fragments of fresh autologous cartilage into the empty perichondrial sheets appears to enhance costal cartilage regeneration and has not

increased the risk of infection. We have used this method in our three groups of patients. There were no complications related to this method. Data from our present clinical experience indicate that chest wall deformity in patients who did not undergo repair of PD in childhood can be repaired during adult years. Our resorbable plaque technique in particular has the same advantages, such as avoiding a second operation for removal of retrosternal struts.

Modifications of the Ravitch technique, by using resorbable plaque or titanium plaque for fixation of sternum, can be easily performed in adult patients with minimum morbidity. The mid-term follow up results and patient satisfaction are excellent.

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