Repair of Pectus Excavatum and Carinatum in Adults

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BACKGROUND: There is sparse published information regarding the repair of pectus chest deformities in adults. This report summarizes our clinical experience with the surgical repair of pectus excavatum and carinatum deformities in 25 adults.

METHODS: During the past 11 years, 25 patients 20 years of age or older (mean 31) with symptomatic pectus excavatum (23) or carinatum (2) deformities underwent surgical repair using a temporary internal sternal support bar.

RESULTS: Each of the patients with decreased stamina and endurance or dyspnea with exercise experienced marked clinical improvement within 4 months postoperation. Exercise-induced asthma was improved in 6 of 7 patients; chest pain was reduced in each of 9 patients. Postoperative complications included pneumothorax (1), keloid (2), and discomfort from sternal bar (2). The sternal bar was removed 7 to 10 months postoperation in 19 patients; there has been no return of preoperative symptoms or recurrent depression in any patient with a mean follow-up of 4.8 years.

CONCLUSIONS: For adults who have symptoms and activity limitations related to uncorrected pectus chest deformities, surgical repair can be performed with low morbidity, low cost, minimal limitation in activity, and a high frequency of symptomatic improvement. The operation in adults is more difficult than in children, although the results are similar. *Am J Surg.* 1999;177: 121–124. © 1999 by Excerpta Medica, Inc.

Pectus excavatum chest deformities occur in more than 1 of every 1,000 births and become more apparent during the period of rapid skeletal growth in early adolescence.[1] Deep inspiration commonly accentuates the pectus depression. The heart is often displaced into the left chest, and pulmonary expansion during inspiration is confined. Respiration during exercise often utilizes more extensive diaphragmatic excursions to compensate for the diminished chest wall expansion. Easy fatigability and decreased stamina and endurance with exercise often occur during early adolescence. Occasional patients experience chronic bronchitis, asthma, or bronchiectasis during adolescence. Spontaneous regression of pectus excavatum or carinatum rarely occurs. The effect of pectus excavatum on longevity is unclear; however, severe pectus deformities are rarely found in autopsies on persons over age 65 years.

Many improvements in the technique for surgical correction of pectus excavatum have evolved during the 8 decades since the first repairs were performed.[2–6] Pectus excavatum deformities are currently repaired in childhood with a low incidence of complications, a high frequency of improvement in respiratory symptoms and exercise limitation, excellent cosmetic results, and at low cost with short hospital stay.

During the past 11 years we have been consulted by an increasing number of patients over the age of 20 years who have severe untreated pectus deformities with worsening symptoms and limitations and who are very desirous of having surgical correction. There is sparse published information regarding the repair of pectus deformities in adults. The present report summarizes our clinical experience in the surgical repair of pectus chest deformities in 25 patients 20 years of age or older.

MATERIALS AND METHODS

During the 30-year period from 1968 through 1998, 373 patients underwent repair of pectus excavatum, and 45 had correction of carinatum deformities at the UCLA Medical Center. During the same period 25 of the patients were operated upon when they were 20 years or older, all during the past 11 years (19 during the past 5 years). The age of these adult patients has ranged from 20 to 52 years (mean 31) at the time of operation. Only 3 of the 25 patients were female. Twenty-three patients had excavatum and 2 had carinatum deformities. The pectus depression was evident within the first few months of life in 21 of the excavatum patients; later recognition of the deformity was observed in the 2 patients with pectus carinatum. Twenty-four of the operations were performed by one surgeon. The period of follow-up has extended from 4 months to 11 years (mean 4.8).

The most frequent symptom, which was common to all of the patients, was progressive loss of stamina and endurance with exercise. Many had been able to participate in competitive athletic activities during early adolescent years, but then found it progressively more difficult to keep up with their peers. Eight patients had difficulty climbing more than two flights of stairs without becoming short of breath. Thirteen patients had more frequent respiratory infections than other persons of the same age. Seven patients had exercise-induced asthmatic symptoms. Nine patients experienced aching pain in the lower anterior chest after exercise, with 2 having pain even at rest. Functional

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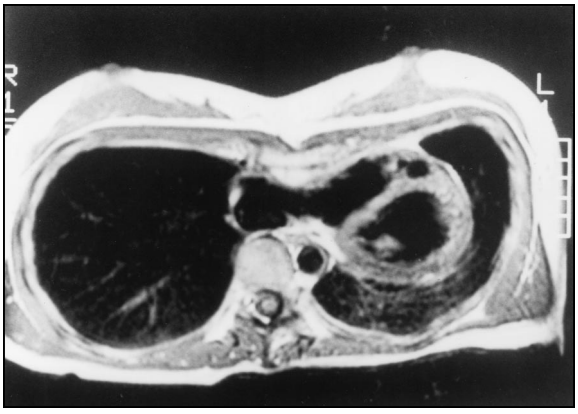

Figure 1. Magnetic resonance imaging scan of chest from 36-year-old woman with severe pectus excavatum with marked anterior-posterior flattening of the chest and compression of the right ventricle.

heart murmurs were present in 6 patients. Seven patients had mild to moderate scoliosis, none requiring surgical management. Body-building exercises commonly resulted in worsening of the cosmetic appearance. None of the patients had other major medical disorders, such as cancer, stroke, coronary artery occlusion, or chronic pulmonary disease.

Seventeen patients had electrocardiographic evidence of right ventricular strain and 5 had mitral valve prolapse. Three patients had a diastolic filling pattern suggesting constrictive dynamics. All 23 patients with excavatum deformities had displacement of the heart into the left chest on radiographs. The distance between the posterior aspect of the sternum and the anterior surface of the spine ranged from 3.5 cm to 7.0 cm at the deepest level of pectus depression. The pectus severity index as determined by dividing the inner width of the chest at the widest point, by the distance between the posterior surface of the sternum and anterior surface of the spine ranged from 3.0 to 6.7 (mean 5.3). The mean pectus severity index of normal adults is 2.56, and the mean index of patients undergoing pectus excavatum repair in the large series reported by Haller and associates[8] was 4.42. Chest computed tomography or magnetic resonance imaging scans were performed on 6 patients and showed narrow anterior-posterior chest diameters with compression and displacement of the heart (**Figure 1**).

The operative technique used for each of the 25 patients was a modification of that described by Ravitch[3] and Welch[5] and extensively detailed in previous reports.[7] The repair of pectus excavatum includes the following essential features: (1) A transverse curvilinear incision is made midway between nipples and costal margin extending from mid nipple line bilaterally. (2) Limited skin flaps are elevated over the pectoralis muscles using needle point electrocautery to minimize blood loss. (3) The pectoralis major muscles are reflected laterally from attachments to the sternum and costal cartilages, and the abdominal muscles are mobilized from the lower costal cartilages. (4) The perichondrium is incised on the mid anterior surface of the lower four to five costal cartilages bilaterally, extending from the costochondral junction to the sternum. (5) Abnormal costal cartilages are resected subperichondrially, carefully preserving the perichondrium. (6) The xiphoid is detached from the sternum. (7) The intercostal muscles and perichondrial sheaths of the involved ribs are transected from the sternum. (8) The lower retrosternal space is mobilized. (9) The pleura is incised on the right side of the mediastinum, and a small chest tube is inserted. (10) A transverse anterior wedge osteotomy of the sternum is made at the level where the sternum depresses posteriorly. (11) The posterior table of the sternum is gently fractured without displacement and then elevated to the desired position. (12) Nonabsorbable sutures are placed through the anterior table of the sternum across the osteotomy. (13) A stainless-steel (Adkins) strut (Baxter Healthcare Corp., Operating Room Division, McGaw Park, Illinois) is placed across the lower anterior chest to support the tip of the sternum and is attached to the appropriate rib on each side (fifth or sixth rib) with wire.[9] (14) The xiphoid and perichondrial sheaths are sutured back to the sternum. (15) The pectoralis and abdominal muscles are sutured together over the sternum. (16) The skin is closed with subcuticular absorbable sutures and steristrips or staples.

Thorough hemostasis is achieved with electrocautery, and the wound is copiously irrigated with antibiotic solution (Ancef) throughout the operation. The chest tube is removed within 24 hours after operation. Intravenous antibiotic (Ancef) is given for 3 days, and oral antibiotic (Keflex) is given for 4 additional days. Postoperative pain was remarkably mild in all patients and was controlled with intravenous analgesics for the first 2 postoperative days and by oral medications thereafter.

The duration of the operation averaged 3.1 hours and the total period of hospitalization rarely exceeded 4 days (mean 3.6). None of the patients received blood transfusions. Full physical activity including strenuous exercise was resumed by almost all patients within 8 weeks. The substernal strut was removed on an outpatient basis between 7 and 10 months after repair with the patient under light general anesthesia.

RESULTS

Each of the patients with preoperative limitation in stamina and endurance with exercise experienced marked improvement within 4 months after operation, and each was able to participate in vigorous exercise, including running, swimming, hiking, and tennis, before removal of the sternal bar (**Figure 2**). Twelve of the 13 patients with frequent respiratory infections had a decrease in frequency and severity within 4 months. Six of the 7 patients with exercise-induced asthma experienced fewer episodes of wheezing and a decrease in requirement for medications. Each of the 9 patients with chest pain noted considerable improvement within 3 months. Eleven of the 12 patients who underwent preoperative measurement of vital capacity with an incentive spirometer experienced improvement within 6 months (mean improvement 11%). Although objective measurements of physiologic improvement following operation are not available for all patients, 21 showed a shifting of the heart from the left chest to a normal position on chest radiograph. Functional heart murmurs were no longer audible in 4 of the 6 patients.

Postoperative complications included unintentional

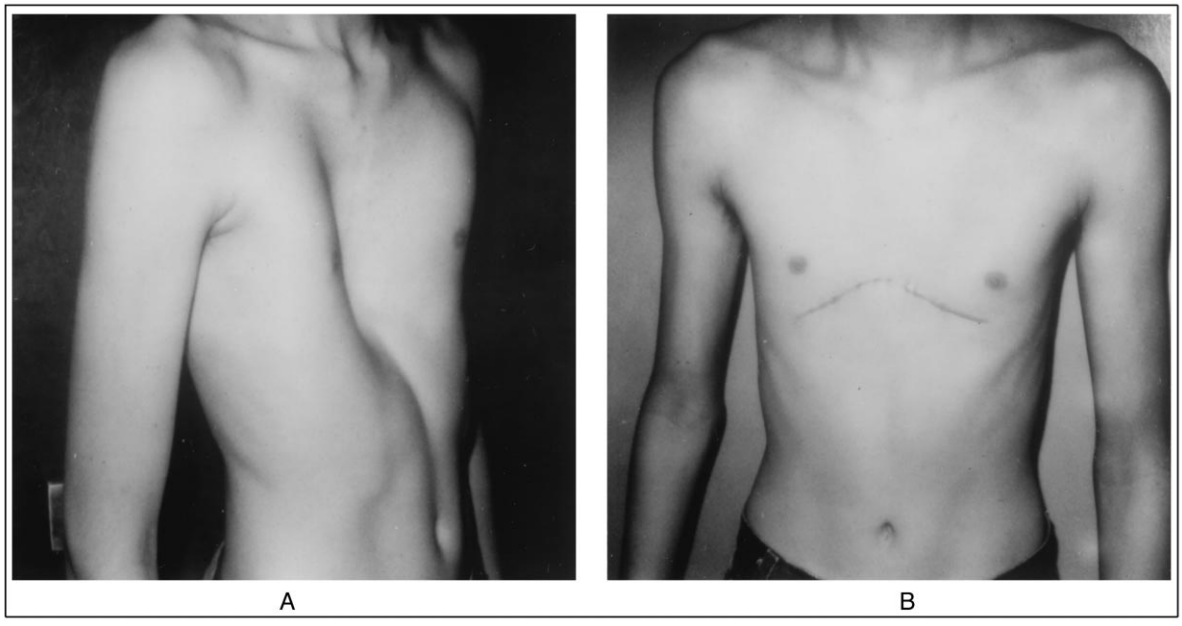

Figure 2. A. Twenty-one-year-old man with uncorrected pectus excavatum deformity and marked displacement of heart into left chest. **B.** Postoperative appearance 2 months following surgical repair.

pneumothorax in 1 patient and atelectasis in another. Two patients developed mild keloid formation. There were no wound infections. There were no deaths within 12 months after operation. Only 2 patients indicated mild discomfort from the sternal bar. In 1 patient the sternal bar became incorporated within the neocartilage and could not be safely removed.

COMMENTS

Symptoms from pectus excavatum are infrequently recognized during early childhood, apart from an unwillingness to expose the chest while swimming or participating in other athletic or social activities. The majority of parents are therefore advised by well-meaning family physicians or pediatricians that (1) the deformity will improve with age; (2) the malformation produces few symptoms and is primarily a cosmetic problem, and (3) that surgical repair is dangerous, minimally effective, and unnecessary. It is clear that each of these views is incorrect with our present knowledge of pectus deformities and the current techniques for surgical repair based on a large clinical experience with long-term follow-up.

During adolescent years when the bony skeleton experiences rapid growth, the majority of patients will be observed to develop a flat thorax with decreased anteroposterior diameter. As noted by Ravitch,[10] "the volume of the thoracic cavity is necessarily decreased, with varying degrees of compression, displacement and rotation of the heart, lungs, and great vessels." In adolescent years there is commonly some recognized disability, which may only be of the order that allows a child to run but not to race, to hike but not to fall behind when going uphill, or to "fool around" the basketball court but not to play a game. Many teenagers will indicate easy fatigability with exercise, increased frequency of respiratory infections, and exercise-induced asthmatic symptoms. Some very competitive children have been able to compensate for the pectus-induced limitations in chest expansion in short duration athletics by wider diaphragmatic excursions at a greater expense of energy. Objective measurements to document the severity of physical limitations caused by pectus excavatum have been imprecise and often confusing. No consensus has been achieved over the past few decades regarding the degree of cardiopulmonary impairment that occurs with this common deformity, and how much improvement results after surgical repair.[11]

It was noted by Ravitch[12] in 1951 that in occasional young adults with uncorrected pectus excavatum, the symptoms may progress to severe incapacity with exercise intolerance, tachycardia, and cardiac failure, all of which may be dramatically improved by surgical repair. He cited several reports of patients who died with dyspnea and cardiac failure, in whom at autopsy no abnormality could be found, except a severe pectus excavatum.[10]

During the past few years an increasing number of patients over the age of 20 years with uncorrected pectus excavatum have sought advice regarding the surgical repair of their deformities because of worsening symptoms. Deviation of the heart into the left chest with compression of the right ventricle by the sternum can be of dramatic proportion (Figure 1). The distance between the posterior aspect of the sternum and the anterior surface of the spine in 8 patients was less than 5 cm (this distance is more than 10 cm in most normal adults; **Figure 3**). The significance of severe cardiac compression and displacement on aging patients with progressive coronary arterial stenosis and other cardiovascular abnormalities is currently largely speculative, although 3 patients in the present group of patients with exercise intolerance and angina-like chest pain experienced dramatic improvement following pectus repair. The decision to operate has been based on the severity of

Figure 3. Lateral magnetic resonance imaging study of chest showing severe compression of mediastinal structures by lower sternum. The distance between the posterior surface of the lower sternum and the anterior surface of the spine is less than 3 cm.

the pectus deformity as noted on physical examination and chest radiograph (pectus severity index) or computed tomography scans, and on the severity of symptoms rather than pulmonary function tests.

Although the technical aspects of the pectus repair were more tedious than in children, the postoperative recovery and the long-term results have been similar to that for younger patients. The costal cartilages are usually brittle and thick, and often must be scooped out from the perichondrial sheaths with a rongeur rather than being stripped out with a small elevator. As with children, the Adkins substernal support bar has provided immediate stability to the chest that has eliminated paradoxical respiratory movements and helped to minimize chest pain and atelectasis. Epidural analgesia has not been used during the past 5 years, as it has been unnecessary and also prolongs the hospital stay. Costal cartilage regeneration in the adult patients has been slightly slower than in children, although all patients had a very stable chest wall within 10 weeks. Removal of the sternal bar within 7 to 10 months has not resulted in return of preoperative symptoms or recurrent depression in any of the 19 patients who have had the bar removed, with a mean follow-up of 4.8 years.

CONCLUSIONS

Data from the present clinical experience suggests that many patients who do not undergo repair of severe pectus chest deformities in childhood will experience worsening symptoms in adult life. For those adults who have symptoms and activity limitations related to pectus chest deformities, surgical repair can be performed with low morbidity, low cost, minimal limitation in activity, and a high frequency of symptomatic improvement. Repair of pectus deformities is technically easier and is therefore encouraged during childhood; however, for those patients who did not undergo operation as children, repair during adult years should be considered as a recommended treatment option.

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