Pectus Excavatum in Adult Women: Repair and the Impact of Prior or Concurrent Breast Augmentation

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Background: Women present with pectus excavatum five times less frequently than men. Adult women may have additional, associated cosmetic factors, including hypoplastic or asymmetric breasts, or prior augmentation. The authors evaluated the impact of prior or concurrent cosmetic breast surgery in an adult female cohort undergoing repair of pectus excavatum deformity.
Methods: A retrospective review was performed of women (≥18 years old) who underwent pectus excavatum repair at a single institution from January of 2010 to September of 2013.
Results: Pectus excavatum repair was performed on 47 women with a median age of 35 years (range, 18 to 63 years). Mean pectus severity index was 6.2 (range, 3.1 to 16). All patients had physiologic symptoms as the primary purpose for seeking repair. Twenty patients (43 percent) presented with existing implants or the desire for implants at the time of repair. Fifteen patients (32 percent) had a history of implant placement including prior breast augmentation (n = 14) and/or pectus implant (n = 4). Concurrent augmentation (n = 5), breast implant exchange (n = 8), and/or removal of chest wall implants (n = 4) was performed during repair. Morbidity included one implant-related hematoma. Complications and hospital stay were not significantly different for patients undergoing primary repair alone versus those with prior or concurrent augmentation.
Conclusions: Breast cosmesis was a concern in nearly half of adult women presenting for pectus excavatum repair. The authors' experience suggests neither prior nor concurrent breast augmentation increases the risk of complications in repair. The authors recommend that cosmetic breast surgery be performed concurrently with pectus excavatum repair. (*Plast. Reconstr. Surg.* 135: 303e, 2015.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III.

Pectus excavatum is the most common congenital chest wall abnormality in childhood and occurs in approximately one in every 300 to 400 white male births.[1–4] Current literature suggests that pectus excavatum is identified five times less commonly in female subjects.[1] Although mild cases are often asymptomatic, severe cases may be associated with cardiac compression and physiologic symptoms.[5–7] Impaired cardiopulmonary function may manifest as dyspnea with exercise, progressive loss of endurance, inability to keep up with peers, chest pain with activity, palpitations, tachycardia, exercise-induced wheezing, and early fatigability.[4,5,8–10] Cardiopulmonary function has been shown to improve after surgical correction of pectus excavatum.[9,10] In addition, pectus excavatum may play an important psychosocial role in body image and may have a major effect on the interplay that occurs between a patient and society.[3,11]

Female patients present for evaluation of pectus excavatum less often than their male counterparts. This may be because of the male predilection for the disease, but may also be secondary to

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female breast development concealing the severity of the deformity.[12,13] Surgeons need to be aware of the potential for anterior chest wall defects in women who present with hypoplastic or asymmetric breasts.[14,15] Placement of unilateral or bilateral breast implants and custom chest wall prostheses to fill the pectus excavatum deformity have been described to improve cosmetic chest wall appearance (Fig. 1).[3,12]

Some patients develop increased physiologic symptoms with age, even in late adulthood, and present for evaluation and treatment of their pectus excavatum deformity as adults.[6,8,13] Although pectus excavatum is commonly repaired in adolescence, the increased recognition of the cardiopulmonary impact has resulted in adults presenting for surgical repair.[4] Many adult patients present for chest wall correction for the dual purpose of treating the physiologic issues related to their deformity and a desire for an improved cosmetic appearance.[12,16]

For women, breast cosmesis is an important concern when considering correction of their pectus excavatum deformity. The added complexity of existing implants and requests for breast augmentation has received little medical attention in the literature. Publications on pectus excavatum repair specifically in female patients are limited, and concomitant breast augmentation or implant exchange at the time of repair has been discouraged in favor of later staged procedures by some.[12,13,17] A retrospective review of women presenting to our institution for surgical correction of pectus excavatum is evaluated in this cohort. Demographics, symptoms, and surgical technique including concurrent breast augmentation are discussed, with a review of pectus excavatum patients having existing implants from

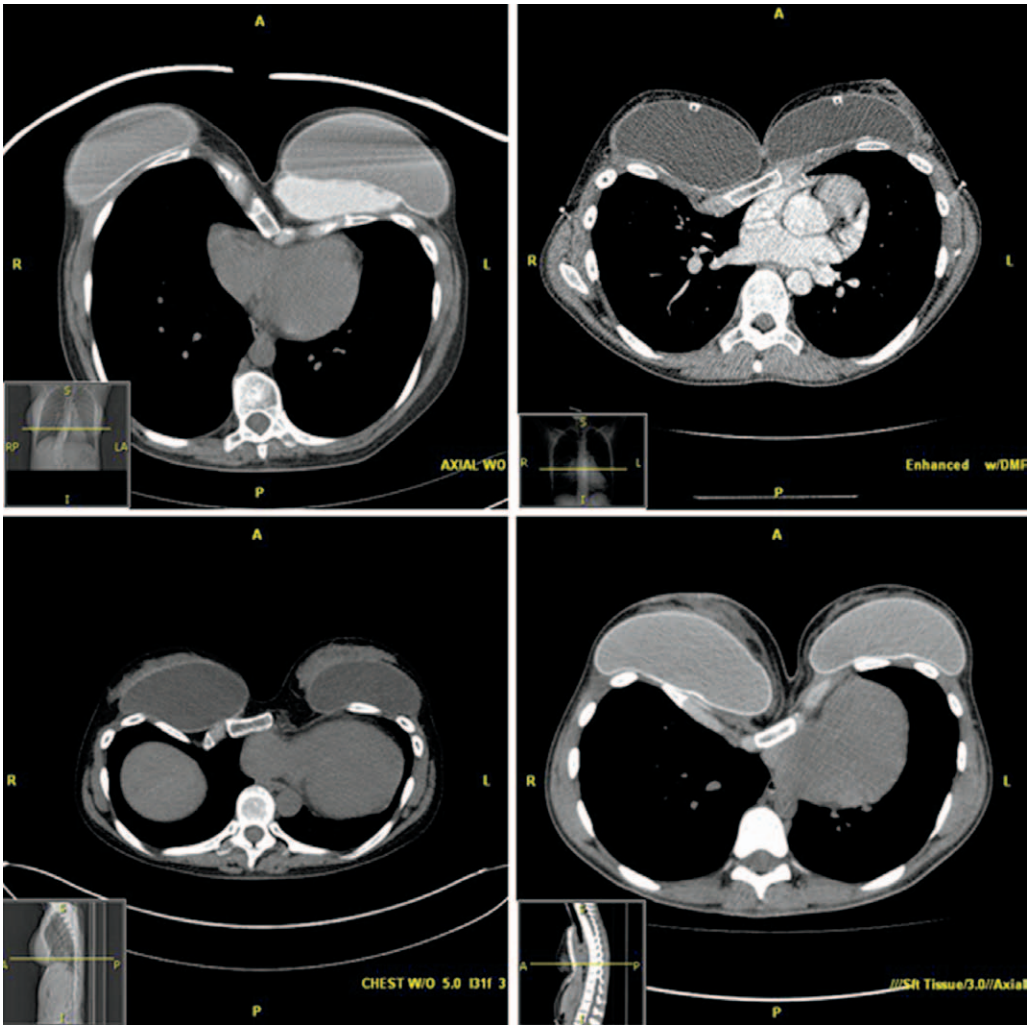

Fig. 1. Thoracic computed tomographic scans of patients with pectus excavatum noting deformity and prior breast implants and a custom chest wall prosthesis (*above*, *left*). Used with permission of Mayo Foundation for Medical Education and Research.

prior breast augmentation and those requesting augmentation.

PATIENTS AND METHODS

A retrospective review was performed on all female patients who underwent pectus excavatum repair at the Mayo Clinic Arizona from January of 2010 to September of 2013. Only patients who underwent surgical intervention were included. Information regarding patient demographics, disease characteristics, and surgical variables was collected. The indications for surgery were determined based on subjective impact of symptoms, objective data collected from chest wall imaging, pulmonary function tests, electrocardiography, and echocardiography. The pectus defect was quantified by a severity index (Haller index), which was calculated using computed tomographic or magnetic resonance imaging scans (transverse diameter of the chest divided by the anteroposterior diameter, preferably on expiration for a more accurate measurement of severity).[18,19] One patient was excluded from calculations because of multiple prior repairs with subsequent chest deformity that could not be accurately characterized.

Patients with prior breast augmentation surgery for cosmetic correction of the pectus excavatum defect and those desiring augmentation concurrently with their repair were identified. Combined surgery was planned with a plastic surgeon preoperatively. Often, existing implants were either asymmetric in size or in need of replacement because of age or capsule problems. Depending on the location of implants (either subglandular or subpectoral), the need for creating a protective barrier between the pectus bars and implants was determined to minimize the risk of possible contact or infection.

The principal outcomes were perioperative complications within 30 days of the initial operation and impact of breast augmentation (prior or concurrent) on the surgical pectus excavatum repair. Analysis was performed using descriptive statistics. This study was approved by our institutional review board and consent waived providing deidentification of data.

Surgical Techniques

Minimally invasive repair of pectus excavatum was used for all but four patients that required combined procedures with open repair including sternal and rib osteotomies because of extensive deformity. In each procedure, correction of the deformity was performed first, and implants were placed after the support bars were secured.

Pectus Excavatum Minimally Invasive Repair

The patient was intubated with a double-lumen endotracheal tube to allow for single-lung ventilation. The patient was placed in supine position with two rolls placed longitudinally under the back to elevate the torso. The arms were padded with foam and tucked at the sides, allowing easy access to both the anterior and lateral aspects of the chest wall for placing and affixing bars. Bilateral 3- to 4-cm incisions were made at the inframammary crease. Dissection was carried directly onto the chest wall, and submuscular pockets were developed under the pectoralis muscles and along the lateral chest wall. For patients with existing implants requiring exchange, the capsule was opened and the implants removed to facilitate pectus repair (Fig. 2). For patients with existing implants not being exchanged, the implant and associated capsule were carefully avoided by dissection under the capsule.

Initially, a 5-mm thoracoscopy port was placed through the inframammary incision on the right to visualize the pleural space. Carbon dioxide insufflation was used and a second 5-mm port was placed under direct visualization in a rib space above the diaphragm. The anterior mediastinum was then assessed. For deep pectus excavatum defects, a Lewin Spinal Perforated Forceps (V. Mueller NL6960; CareFusion, Inc., San Diego, Calif.) was placed into the bone of the lower sternum through 2-mm stab incisions on the lateral sides of the sternum and closed. The Lewin forceps was then attached to a table-mounted Rultract Retractor (Rultract, Inc., Cleveland, Ohio) to elevate the sternum and defect (Fig. 3) as has been described previously.[20] With the sternum elevated, the anterior mediastinal space was dissected across to the left thoracic space using thoracoscopic instruments. The Pectus Introducer (Biomet Microfixation, Jacksonville, Fla.) was then directed through a right anterior intercostal space under the sternum, and exited the corresponding left anterior intercostal interspace. A no. 5 FiberWire (Anthrex, Naples, Fla.) was attached to the dissector and pulled back through to guide the stainless Pectus Bar Implant (Biomet Microfixation) into position. Two or three bars were sized and custom-shaped in the operating room to correct the patient's defect. The bars were passed using the FiberWire guide and then rotated into position. Circumferential rib fixation, also using FiberWire, held the bars in position (Fig. 4). At

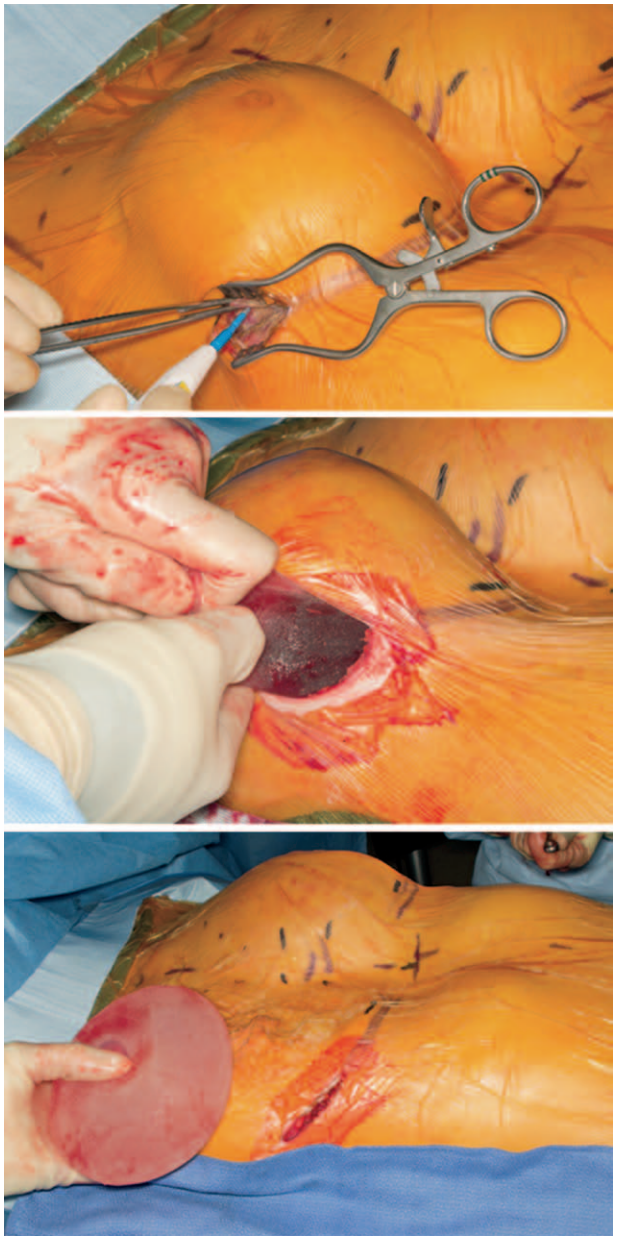

Fig. 2. Intraoperative photographs. (*Above*) An inframammary incision is used to access the implant cavity. (*Center* and *below*) The existing breast implant is removed, which allows the pectus excavatum defect to be seen more prominently.

least two or three fixation sites per side were used to circumferentially affix the bar to the underlying rib. No lateral stabilizers were used. Chest tube(s) were placed at the end of the procedure to evacuate any residual pneumothorax and removed in 24 to 48 hours.

Concurrent Breast Augmentation

For patients undergoing primary breast augmentation at the time of pectus excavatum repair, implants were preferentially placed in the subglandular position. This position was chosen over the subpectoral or dual-plane technique in an effort to prevent potential complications related to long-term contact of the implant with the support bars. The need to place an additional barrier between the support bars and the breast implant depended on the overall position of the bars and the amount of muscular coverage. Based on techniques derived from implant breast reconstruction, acellular dermal matrix (AlloDerm; LifeCell Corp., Bridgewater, N.J.) was used as an interposition layer and lower pole sling for support and positioning of the implants in the majority of cases.[21] After completion of the repair and securing of bars, the pectoralis muscles were reapproximated, and a subglandular pocket was created. Access was gained through the inframammary incision used for pectus bar placement, and the implant was then positioned in the subglandular plane. For patients with previous augmentation, acellular dermal matrix was secured to the chest wall and bars to form a protective barrier, preventing contact between the bars and implants and also preventing lung herniation in patients with a history of pectus surgery. The acellular dermal matrix was sized to provide coverage of the exposed chest wall and stainless steel support bars, and secured with absorbable sutures (Fig. 5). The area was irrigated with antibiotic solution, and two bulb-suction drains were positioned under and over the pectoralis muscles through separate incisions. Using a no-touch technique,[22] the new implants were placed into the pocket using a Keller funnel (Keller Medical, Inc., Stuart, Fla.),[23] and positioned in the pocket on top of the acellular dermal matrix (Fig. 6). The overlying subcutaneous tissues were then closed and the acellular dermal matrix was secured to the subcutaneous tissues as a sling to position the implant properly within the pocket. Two-inch-wide skin tape was used to splint the inframammary fold and sternum midline to support the implant position. Patients with newly placed implants were kept on antibiotics until drains were removed.

RESULTS

Female patients constituted 47 of the 216 patients (22 percent) aged 18 years or older undergoing pectus excavatum repair from January of 2010 to September of 2013 (Table 1). The median age of the women was 35 years (range, 18 to 63 years). The median and mean pectus indexes were 5.6 and 6.2, respectively (range, 3.1 to 16). Nine patients had previous failed pectus

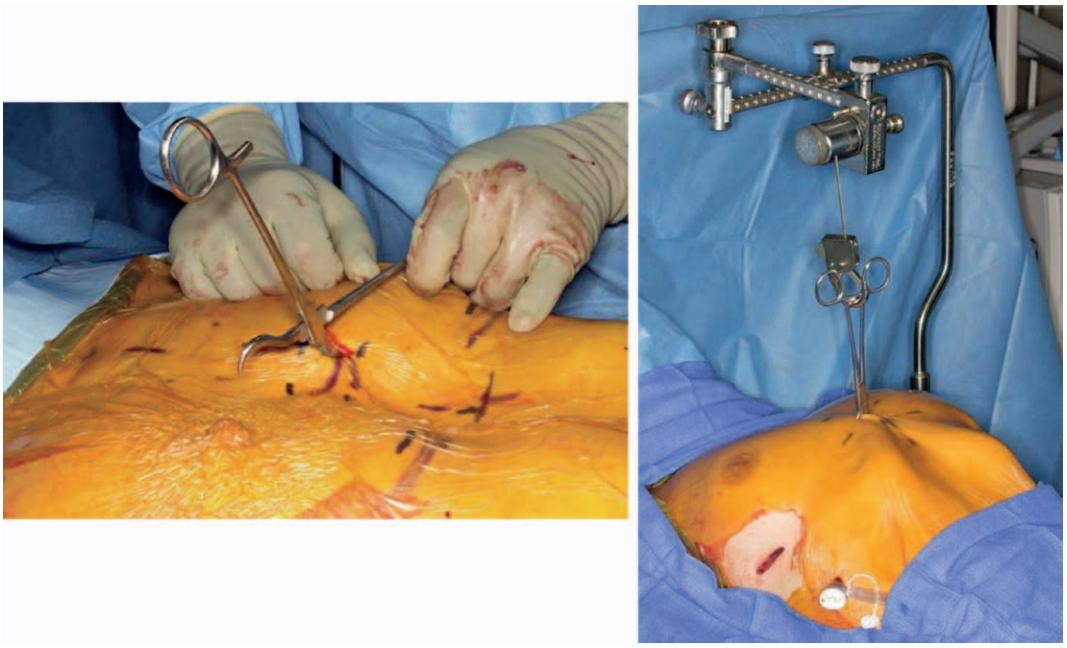

Fig. 3. Intraoperative photographs showing technique of (*left*) placement of the Lewin forceps for deep pectus excavatum defects into the sternum and (*right*) attachment of the Lewin forceps to the table-mounted Rultract Retractor, which elevates the sternum.

excavatum corrections (four open and five Nuss procedures). Eight of these patients subsequently underwent correction with a minimally invasive technique. One patient with prior sternal eversion had significant scar and chest wall calcification, which required extensive open revision.[24] Fifteen patients (32 percent) had prior implant placement for cosmesis. Eleven of these patients had breast implants alone. Three patients had unilateral pectus implants in addition to breast augmentation. One patient had a unilateral pectoral implant for asymmetric pectus excavatum without breast augmentation. Asymmetry (54 percent), inferior costal rib flare (49 percent), and scoliosis (18 percent) were common. Four patients had mixed deformities, with both pectus excavatum and pectus carinatum (9 percent). The majority of patients presented with physiologic symptoms, including dyspnea (94 percent), pain (89 percent), tachycardia/palpitations (81 percent), and exercise intolerance or difficulty keeping up with peers (81 percent). Progression of symptoms was the most common indication for the patient seeking evaluation and treatment of their pectus excavatum (98 percent). Twenty-seven patients had cardiopulmonary exercise testing, with 17 patients (63 percent) having a functional capacity less than 75 percent of predicted. Significant compression of the right heart was documented in 97 percent of patients on computed tomography, magnetic resonance imaging, or echocardiographic evaluation.

Fig. 4. Intraoperative photograph showing the pectus support bar implant in position and secured laterally with FiberWire.

The majority of pectus repairs were performed successfully with minimally invasive repair of pectus excavatum alone [n = 43 (91 percent)]. Four patients underwent a combined thoracoscopic placement of support bars with partial open Ravitch because of combined, complex deformities. Twenty patients (43 percent) presented with existing implants, or requests for breast implants with repair (Table 2). Concurrent augmentation (n = 5), breast implant exchange (n = 8), and/or removal of chest wall implants (n = 4) were performed during repair. Six patients with existing bilateral breast implants

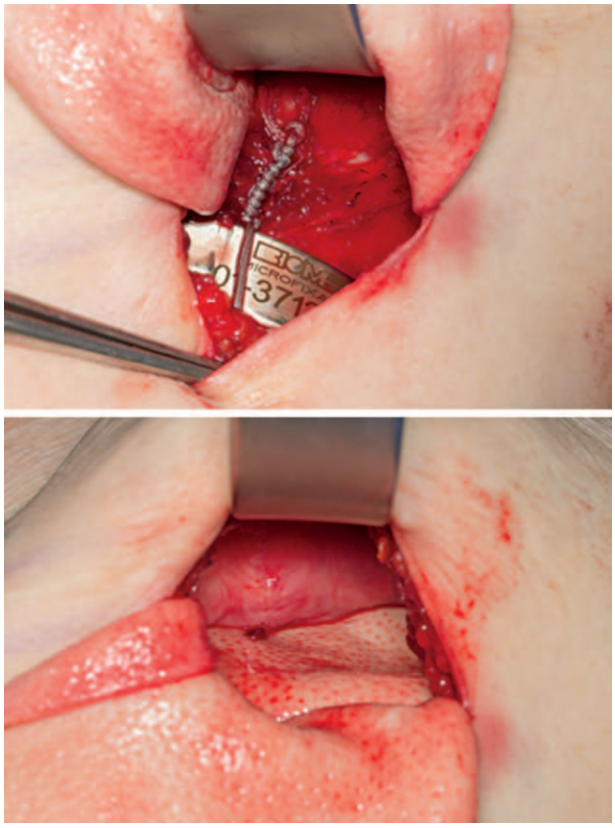

Fig. 5. Intraoperative photographs showing technique of (*above*) acellular dermal matrix being placed as an interposition graft that is secured to the chest wall with absorbable sutures. (*Below*) The acellular dermal matrix is shown as a barrier over the pectus bar implant to prevent contact between the bars and breast implants.

underwent successful pectus repair without implant exchange. Concurrent placement of breast implants was performed in 13 patients (28 percent): five patients with no history of breast augmentation, seven patients with a history of bilateral breast augmentation who underwent implant exchange, and one patient with an asymmetric chest who previously had a right breast implant that was exchanged (Table 3). Implant locations were subglandular in ten patients and subpectoral in three patients. All subpectoral patients had mesh placed between the support bars and the implants. All but three women with subglandular placement of implants had acellular dermal matrix placed (one patient with prior implants without exchange, one patient with right breast implant exchange only, and one patient with new subglandular implants adequately separated by breast tissue from the pectus bars). Two additional patients (4.3 percent) decided to subsequently have breast augmentation performed at 10 days and 73 days after minimally invasive repair of pectus excavatum because of cosmetic preference.

The mean operative time for all patients was 147 ± 74 minutes. Patients who underwent primary repair alone had a mean operative time of 111 minutes, whereas patients undergoing implant exchange averaged 206 minutes. The average time for placement of new implants at the time of primary minimally invasive repair of pectus excavatum was 149 minutes, excluding a patient who underwent additional abdominoplasty. The mean estimated blood loss was 79 ± 140 ml. When looking at minimally invasive repair of pectus excavatum, no difference in estimated blood loss was found for patients undergoing pectus excavatum repair alone versus repair with breast augmentation (37 ml versus 48 ml, respectively) ($p = 0.4$). All patients had at least two pectus bars, and 14 patients had three bars placed. No intraoperative complications occurred. The average length of

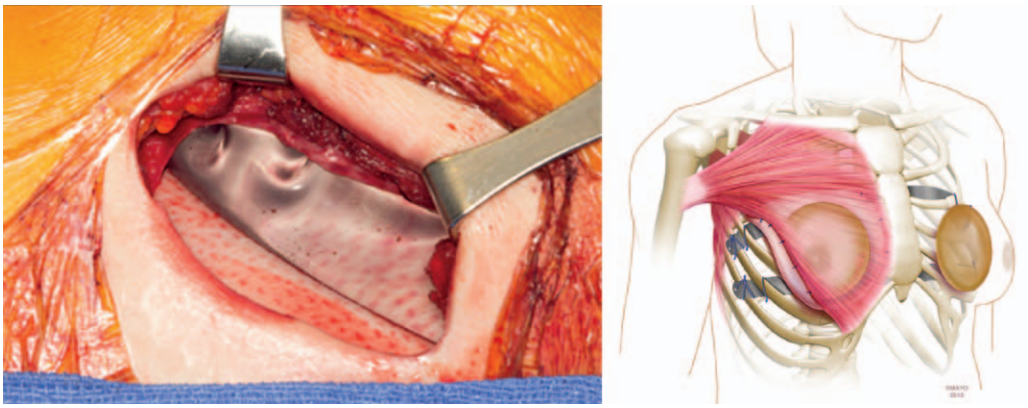

Fig. 6. Intraoperative photograph (*left*) and artistic rendering (*right*) of the final placement of implants, mesh, and pectus implant bar. Relationship to the breast implant from posterior to anterior is as follows: the pectus implant bar is secured to overlying rib with FiberWire, and an acellular dermal matrix is attached to the chest wall, where the breast implant is then placed in a pocket anteriorly.

Table 1. Preoperative Characteristics

	Value (%)
Age, yr	
Median	35
Range	18–63
Pectus index	
Median	5.6
Range	3.1–16
Symptoms	
Dyspnea	44 (94)
Pain	42 (89)
Tachycardia/palpitations	38 (81)
Exercise intolerance or difficulty keeping up with peers	38 (81)
Asthma/cough	14 (30)
Psychiatric involvement	13 (28)
GERD	10 (21)
Previous surgery	
Total patients with existing implants at time of PE repair	15 (32)
Breast augmentation implants	
Bilateral	13 (87)
Unilateral	1 (7)
Chest wall silicone pectus implant	4* (27)
Open repair	4 (9)
Nuss repair	5 (11)

GERD, gastroesophageal reflux disease; PE, pectus excavatum.
*Three patients had concurrent placement of breast implants in addition to a silicone chest wall implant. One patient had a unilateral chest wall implant alone.

stay for all patients including revision was 5.6 days. Excluding the patients with open procedures, the median length of stay was 5.0 days for patients who underwent pectus excavatum repair alone (range, 2 to 16 days) and 5.0 days for repair with concurrent placement of breast implants or implant exchange (range, 3 to 7 days); no significant difference was found between the groups ($p = 0.7$).

Postoperative complications occurred in 28 percent of patients. The most common complication was pleural effusion requiring drainage [$n = 4$ (9 percent)]. One patient developed a hematoma after breast implant placement that required evacuation on postoperative day 1. Additional 30-day postoperative complications included pneumothorax requiring chest tube placement (three patients), pneumonia (two patients), pericardial effusion (one patient), supraventricular tachycardia (one patient), and anemia requiring transfusion (one patient, performed with combined open Ravitch-type procedure). There were no infections secondary to breast implants, and no implants required removal because of complications. One patient without implants and a history of a failed prior Nuss procedure had a breast abscess 3 months after revision of pectus excavatum. This was treated with surgical drainage and intravenous antibiotics; elective bar removal was performed 2 years later.

Four patients had subsequent surgical interventions for additional cosmetic improvements. One pectus excavatum patient underwent resection of a segment of a localized residual carinatum deformity in addition to subglandular silicone implants placed 73 days after her initial repair. An additional patient had subglandular implants placed 10 days after her pectus repair. Two patients had

Table 2. Demographics and Perioperative Information for Patients Undergoing Repair of Pectus Excavatum with and without Implants

	Prior Breast or Pectus Implant Present at Time of Pectus Repair	De Novo Breast Implant Placement Also Placed during Pectus Repair	Minimally Invasive Pectus Repair Alone	Open Extensive Revision
No.	15	5	34	4
Age, yr				
Median	40	33	34.5	49
Range	27–59	18–37	18–63	33–59
Haller index				
Median	5.3	8.3	5.5	4.6
Range	3.1–16	5.6–10.5	3.1–16	3.4–6.5
Previous failed pectus surgical repair	4	1	6	1
Implants exchanged or revised	10	N/A	N/A	3
Prior implant without revision	4	N/A	6	N/A
Chest wall implant removed	4	N/A	2	1
Length of surgery, min				
Median	171	170	112	313
Range	60–388	125–394	60–306	193–394
EBL, ml				
Median	50	50	25	450
Range	25–600	10–600	5–500	50–600
Length of stay, days				
Median	5	6	5	6.5
Range	2–7	4–15	2–16	5–15

N/A, not applicable; EBL, estimated blood loss.

Table 3. Description of the Types of Mentor* Silicone Implants Used, History of Breast Implant, Position of Implant, Volume of Each Implant, and Use of Acellular Dermal Matrix

Patient	Type of Implant	History of Implant	Location	Right (cm^3)	Left (cm^3)	Use of Acellular Dermal Matrix
1	Smooth, round high profile	Yes	Subglandular	600	650	Yes
2	Smooth, round moderate plus profile	Yes	Subglandular	100	N/A	No
3	Smooth, round high profile	No	Subglandular	300	300	No
4	Smooth, round, moderate plus profile	Yes	Subpectoral	375	375	Yes
5	Smooth, round, high profile	No	Subglandular	325	300	Yes
6	Smooth, round high profile	Yes	Subglandular	300	300	Yes
7	Smooth, round moderate plus profile	No	Subglandular	325	325	Yes
8	Smooth, round high profile	No	Subglandular	325	250	Yes
9	Smooth, round high profile	Yes	Subglandular	400	400	Yes
10	Smooth, round, moderate plus profile	Yes	Subglandular	400	400	Yes
11	Smooth, round, moderate plus profile	No	Subglandular	225	225	Yes
12	Smooth, round, high profile	Yes	Subpectoral	400	400	Yes
13	Smooth, round, high profile	Yes	Subpectoral	500	400	Yes
14	Smooth, round, moderate plus profile†	N/A	Subglandular	425	400	Yes
15	Smooth, round, moderate plus profile†	N/A	Subglandular	350	250	No

*Santa Barbara, Calif.
†Sequential implant placed after initial pectus excavatum repair at our institution.

subsequent breast implant exchanges for increased volume and symmetry. Five patients have undergone localized procedures for adjustment of bars or osteophyte resection because of pain issues.

Follow-up was an average of 539 days (range, 39 to 1416 days) and included chest radiographs on days 1, 2, and 4; 1 week; 6 to 8 weeks; and 1 year postoperatively. Only three patients have had their bars removed, with one having subpectoral implants and acellular dermal matrix. There were no complications or difficulties encountered with removal. Cosmetic and radiographic results are shown in Figure 7.

DISCUSSION

Pectus excavatum occurs less frequently in girls and may go unrepaired in childhood or adolescence.[4] Breast implants or chest wall silicone implants are occasionally placed to provide cosmetic improvement; however, women may present for evaluation and repair of their deformity because of cardiopulmonary symptoms. The majority of published techniques for concurrent pectus excavatum surgery and augmentation address the use of silicone implants as a method of improving aesthetics without repair of the deformity.[25–27] Although cosmesis was important to the majority of our patients, all of our adult women had physiologic symptoms as the primary reason for pectus excavatum surgery.

Publications examining adult female pectus excavatum patients and the cosmetic issues of breast hypoplasia are limited.[17] Few studies have been published in the literature discussing pectus excavatum repair in the setting of concurrent breast augmentation.[14,17,28,29] The feasibility and safety of a single-stage procedure for repair and augmentation has been challenged by some authors who have recommended a two-stage procedure with initial repair followed by augmentation at a later date.[13,30] Our study reviews women presenting to our institution for pectus excavatum repair, with a detailed discussion of the cohort having existing implants or requesting breast augmentation. Twenty of our female pectus excavatum patients (43 percent) had concurrent plastic surgical procedures while undergoing repair of the defect.

The primary issue addressed with concurrent repair was prevention of contact between the stainless steel pectus bar and the breast implants. There was a concern regarding long-term risks to the implant integrity from constant contact with the pectus bar[31] and a desire to facilitate future safe bar removal. Acellular dermal matrix was used to create a barrier between subpectoral implants and bars and subglandular implants in patients with insufficient pectoral muscle coverage and an exposed bar. There is a speculative risk of increased infections with the use of multiple implants. Alone, the risk of postoperative infection for breast implants and pectus bars are reported as 2.5 and 5.6 percent, respectively.[32,33] Although there is also additional theoretical risk from using acellular dermal matrix as a barrier between the breast implants and pectus bars,[34] we had no infections, and our study did not identify any increased risk of complications using acellular dermal matrix. The presence or exchange of existing implants slightly increased operative time; however, additional complications did not occur in this subset of patients. The length

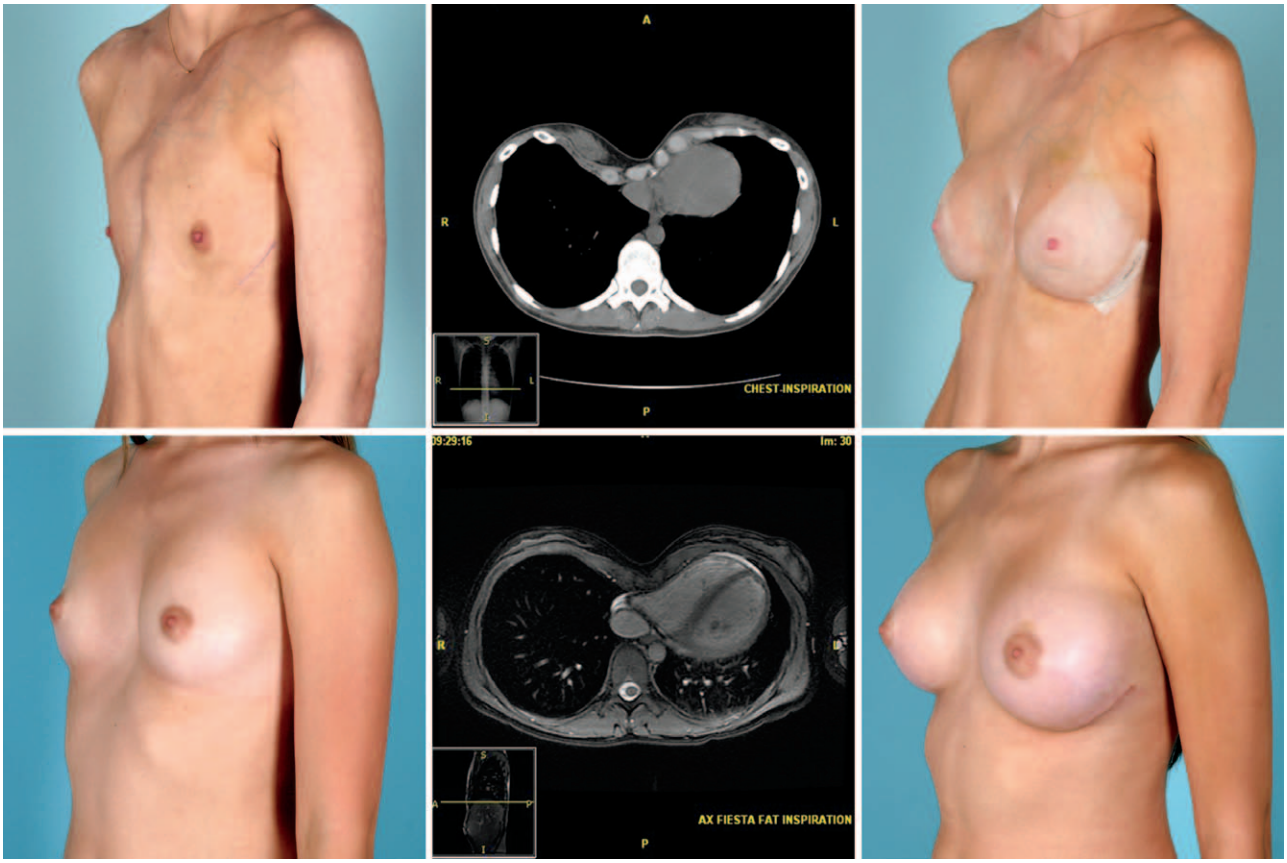

Fig. 7. Preoperative clinical photographs (*left*), computed tomographic scan (*above*, *center*) and magnetic resonance image (*below*, *center*), and (*right*) postoperative clinical photographs of (*above*) a 23-year-old woman with severe pectus excavatum deformity and a severity index of 12.5 and (*below*) an 18-year-old woman with severe pectus excavatum and a severity index of 7.3.

of stay was not significantly different for patients who underwent pectus repair alone compared with those with concurrent placement of breast implants or implant exchange when excluding open pectus procedures.

The limitations of this review are its retrospective nature, short follow-up, and small sample size. We currently recommend removal of support bars at 3 years after repair. Although we have removed the bars in three pectus excavatum patients with implants without complications, we cannot discuss with authority the risk of recurrence and complications associated with bar removal. Although we preferentially placed implants in a subglandular position, it is unclear whether location is an important factor in outcome. Despite these limitations, this series represents an important and underreported cohort of female pectus patients and advocates simultaneous augmentation with pectus excavatum repair.

Our experience suggests that women with pectus excavatum and prior or concurrent breast augmentation may safely undergo chest wall repair without increased risk of complications. Our results support the feasibility of performing a single-stage pectus repair with breast augmentation. Concurrent procedures may therefore be presented as a surgical option for female patients.

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