Surgical treatment and outcomes of pectus arcuatum

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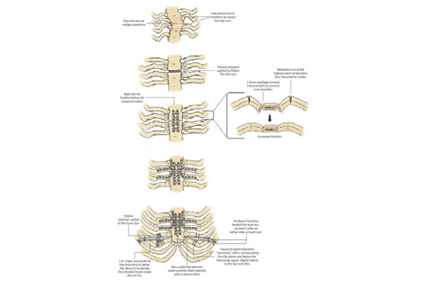
ABSTRACT

Objective: Pectus arcuatum is a rare variant of pectus deformities that can cause varying degrees of cardiac compression. A review of the evaluation, surgical repair, and outcomes of pectus arcuatum is presented.

Methods: A retrospective review of all patients undergoing surgical treatment of pectus arcuatum at a single institution was conducted between January 1, 2010, and May 31, 2024. Descriptive statistics and surgical techniques are presented.

Results: Twenty patients underwent pectus arcuatum repair (median age, 22.9 years; 55.0% males, median Haller index 2.8 [interquartile range {IQR}, 2.2, 3.6]) during the study period. Preoperatively, all patients were bothered by their chest appearance and symptomatic, with the most common symptoms being exercise intolerance (95.0%), chest pain (90.0%), and shortness of breath (90.0%). Preoperatively, cardiopulmonary exercise testing was performed in almost half the patients with abnormal findings (median maximum oxygen consumption, 67.0% of predicted). A hybrid approach with sternal osteotomy and minimally invasive pectus excavatum repair was utilized in 19 out of 20 cases, with 1 case requiring sternal osteotomy only. Single wedge osteotomy was sufficient in most cases (70.0%). Median intraoperative time was 3.5 hours (IQR, 3.1, 4.2 hours). The adoption of cryoablation in 2018 significantly reduced hospital stays, from 5.0 days (IQR, 4.5, 6.0 days) to 3.0 days (IQR, 2.8, 5.0 days) ($P < .001$). At follow-up, all reported cosmetic satisfaction and most reported symptom improvement.

Conclusions: Pectus arcuatum can be successfully repaired with a hybrid surgical approach involving sternal osteotomy and Nuss bar placement. Symptomatic patients should be considered for surgery, with postoperative improvement expected. (JTCVS Techniques 2024;28:194-202)



Pectus arcuatum surgical technique.

CENTRAL MESSAGE

Hybrid minimally invasive repair is the primary surgical approach for symptomatic patients with pectus arcuatum.

PERSPECTIVE

The predominance of case reports and series in literature leads to considerable diversity in diagnosing and surgically treating pectus arcuatum, highlighting the lack of a standardized approach. This publication aims to detail the 13-year surgical approach from a center of excellence, enabling others to adopt it for similar cases.

▶ Video clip is available online.

Pectus arcuatum is a rare variant (<1%) of pectus chest deformities with multiple nomenclatures, including Currarino-Silverman syndrome, pouter pigeon breast deformity, chondromanubrial deformity, and type II pectus carinatum.[1-3] It is characterized by a shortened, wide, unsegmented sternum with manubriosternal protrusion (angle of Louis), often confused with excavatum deformities due to depressed distal sternum and inward sloped lower ribs (Figure 1).[3-8] Causes include congenital sternal nonsegmentation or premature suture obliteration.[4]

Degrees of cardiac compression can occur from the fixed, depressed sternum and lower ribs; however, most publications downplayed the necessity of surgical repair, dismissing it as purely cosmetic.[9-11] With most literature being

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Abbreviations and Acronyms

CD	= Clavien-Dindo
CT	= computed tomography
TTE	= transthoracic echocardiogram
CPET	= cardiopulmonary exercise testing
PFT	= pulmonary function testing
IQR	= interquartile range
TEE	= transesophageal echocardiogram
RVOT-VTI	= right ventricular outflow tract velocity-time integral

only case reports or series, there is significant variability in diagnosis and surgical management, accentuating the absence of a standardized approach.[12-16] This article details the evaluation, surgical repair, and outcomes of pectus arcuatum at a single referral center.

METHODS

Retrospective analysis of consecutive patients undergoing surgical repair of pectus arcuatum by a single surgeon (D.E.J.) at Mayo Clinic Arizona was conducted from January 1, 2010, to May 31, 2024, with institutional review board approval (19-012193; January 8, 2020) and a waiver of individual consent. Patients not undergoing operation were excluded. Clinical information was extracted from electronic medical records. Thirty-day postoperative complications were classified using Clavien-Dindo classification (CD) as either minor (CD 1-2) or major (CD 3-5).[17]

All patients underwent preoperative computed tomography (CT) and, when possible, positional transthoracic echocardiograms (TTE) to assess right cardiac compression. Cardiopulmonary exercise testing (CPET) and pulmonary function testing (PFT) were performed depending on symptom severity and documentation of cardiopulmonary compromise. To guide surgical decision, a holistic assessment was utilized, prioritizing patients' symptoms and objective evidence of cardiopulmonary compromise.

Categorical variables were presented as counts (percentages), whereas continuous variables were presented as median (interquartile range, IQR). All patients were followed with imaging at 6 weeks, 6 months, and a year postrepair, and hardware removal was recommended at 3 years.

Institutional Surgical Approach for Pectus Arcuatum Repair

The patient was positioned supine on gel rolls placed bilaterally along the spine and arms tucked at the sides. Surgical antimicrobial prophylaxis (typically intravenous cefazolin unless contraindicated) was administered prior to skin incision.[18,19] General anesthesia and double-lumen endotracheal intubation were performed. The defect and the lower intercostal spaces were marked for bar placement. Bilateral Nuss incision sites were drawn lateral and inferior to the nipple along the inferior border contour of the pectoral muscle. Ideally, the incision site should straddle the intercostal spaces planned for bar/bars. At the center of the sternal defect, a 3 to 4 cm vertical incision was marked. A baseline intraoperative transesophageal echocardiogram (TEE) was performed. The patient was prepped with chlorhexidine and draped, including Ioban (3M Corp) sheeting. Bilateral intercostal block of T3 to T9 and subcutaneous tissue infiltration surrounding the sternal defect was performed using 0.25 mg/kg bupivacaine up to 60 mg with 10 mg dexamethasone.[20,21]

Bilateral subpectoral pockets were dissected using electrocautery carried down through the soft tissue and submuscular layers. The pockets were then completed by elevating the pectoralis major off the bony chest medially and the serratus laterally. Single lung ventilation was initiated with right isolation, and a 5-mm port inserted thru the right incision. The chest was insufflated with carbon dioxide to 9 to 11 mm Hg pressure. With visualization from a 5-mm articulating-tip Endoeye Flex scope (Olympus), a second 5-mm port was inserted low at the diaphragm. The camera was then moved to the lower port site for the remainder of the case.

Attention was then turned to the open portion of the case. The sternal incision was made and dissection taken down to include elevation of the pectoral muscles bilaterally until the sternum. When present, the associated deformed ribs bilaterally were exposed 1 to 2 cm lateral. Not all patients had abnormal rib insertions and only those that required sternal reattachment in a flush fashion were dissected free. In general, before proceeding with the sternal wedge osteotomy, the fixed and deformed ribs at the associated planned osteotomy site need to be cut. These ribs are often heavily calcified and fixed with bulky insertions that obstruct the ability to perform the wedge osteotomy and prevent the sternal reduction once cut. An osteotome or oscillating saw was used to cut and free the abnormal rib insertions from the sternum (Figure 2). Initially, no redundant cartilage was excised. Depending on

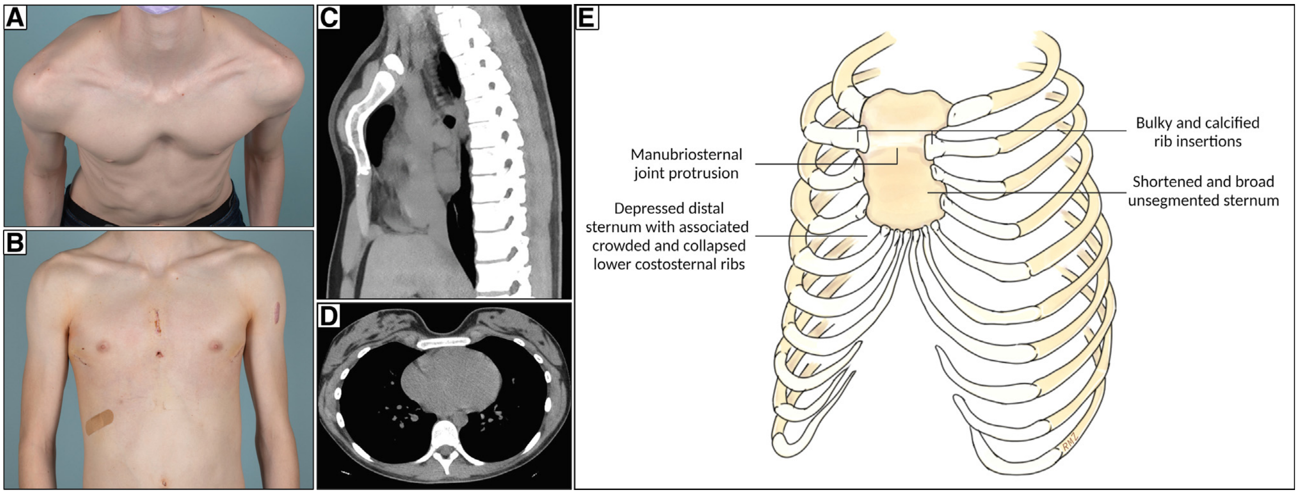


FIGURE 1. A, Picture of a patient with pectus arcuatum showing typical sternal protrusion with lower inward depression. B, Picture postsurgical repair. C, Lateral computed tomography (*CT*) view of a shortened unsegmented sternum protruding at the manubriosternal junction, characteristic features of pectus arcuatum. D, Axial CT view of the broadened sternum typically seen in pectus arcuatum. E, Illustration of the major pectus arcuatum features.

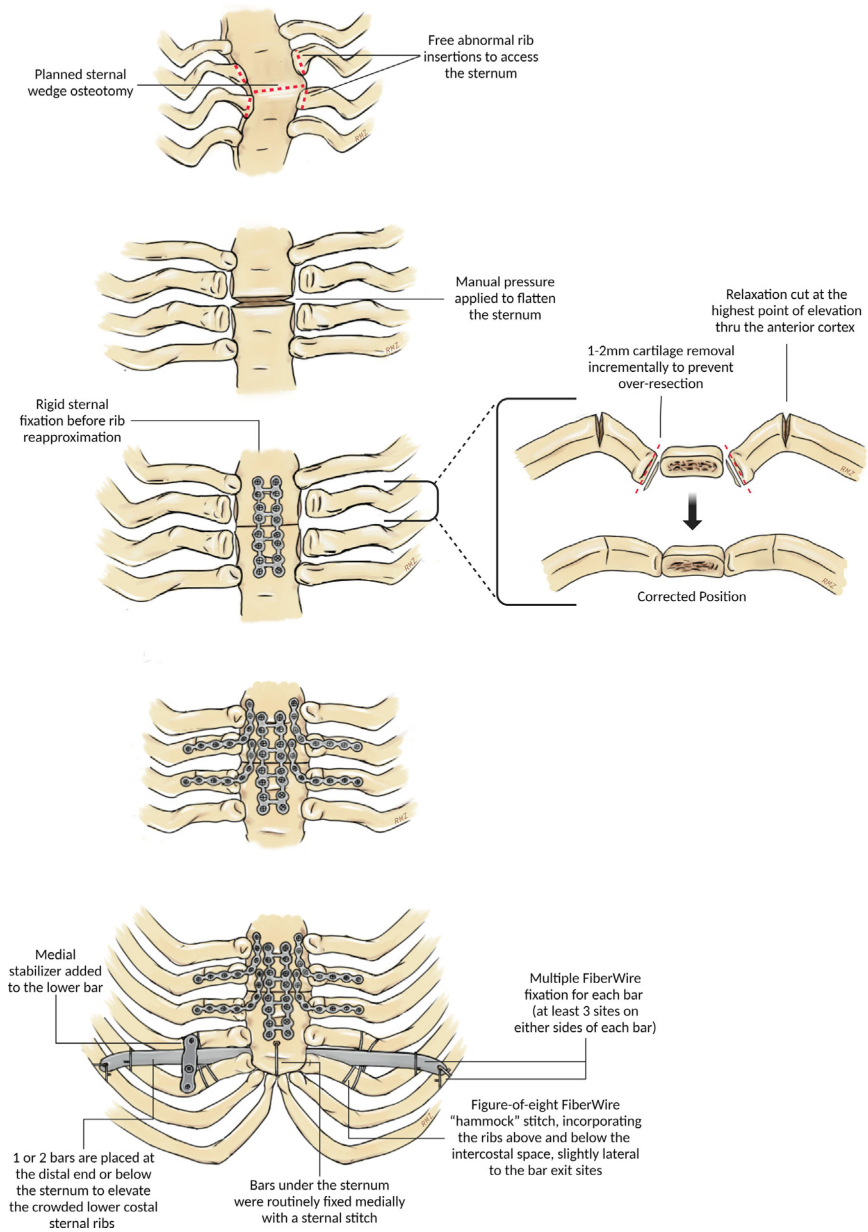


FIGURE 2. An illustration of the major steps involved in surgically repairing pectus arcuatum using a hybrid approach.

the degree and length of sternal angulation, 1 or 2 sternal osteotomies were planned. The sites of sternal osteotomy were marked with cautery (Figure 3, *A*). To prevent overcutting sternum, a few millimeters wide segment was marked at the height of the curve and using an oscillating saw, a 3- to 4-mm wedge was taken out of the anterior table. In general, patients with one central point of elevation had a single osteotomy (Figure 4, *A*). However, in patients with longer curved sternum, 2 cuts at the elevation points were needed to flatten completely (Figure 4, *B*). A lateral CT view can help plan these cuts before surgery. It is recommended not to completely cut the sternum, but only its anterior table in a wedge fashion (Figure 3, *D*). The saw blade was held at an angle to cut toward the other side. Alternating sides, the 2 cuts connect while preserving the posterior sternal table (Figure 3, *B* and *C*). An osteotome can be used to clear debris and adjust the wedge depth if needed. The wedge was removed followed by Nuss bar placement for lower chest elevation. Before placing bars, one must confirm complete sternal reduction and evaluate the need for another osteotomy. To do so, the chest was manually elevated superioly and depressed inferiorly. Apart from 1 patient with minimal depression, bar insertion was performed on all patients, as we routinely recommend.

Pectus excavatum was corrected with bars using our previously detailed technique[22,23] (Figure 2). Before placing the bars, the involved intercostal spaces were routinely supported by placing a figure-of-8 FiberWire (Arthrex Inc) hammock stitch, incorporating the ribs above and below the intercostal space, slightly lateral to the bar exit sites. This allows the bars to rest on the suture rather than the intercostal space, decreasing the risk of intercostal muscle stripping and subsequent bar rotation or migration.[22] With arcuatum patients, the shortened sternum causes the lower costal cartilages to compress the heart, so a low bar should be placed inferior to the sternum to elevate these cartilages. Fixation of these bars can be difficult with higher risk of rotation. FiberWire was used for circumferential fixation of the bars and the ribs. Additionally, bars under the sternum were routinely fixed medially with a sternal stitch, and bars inferior to the sternum were

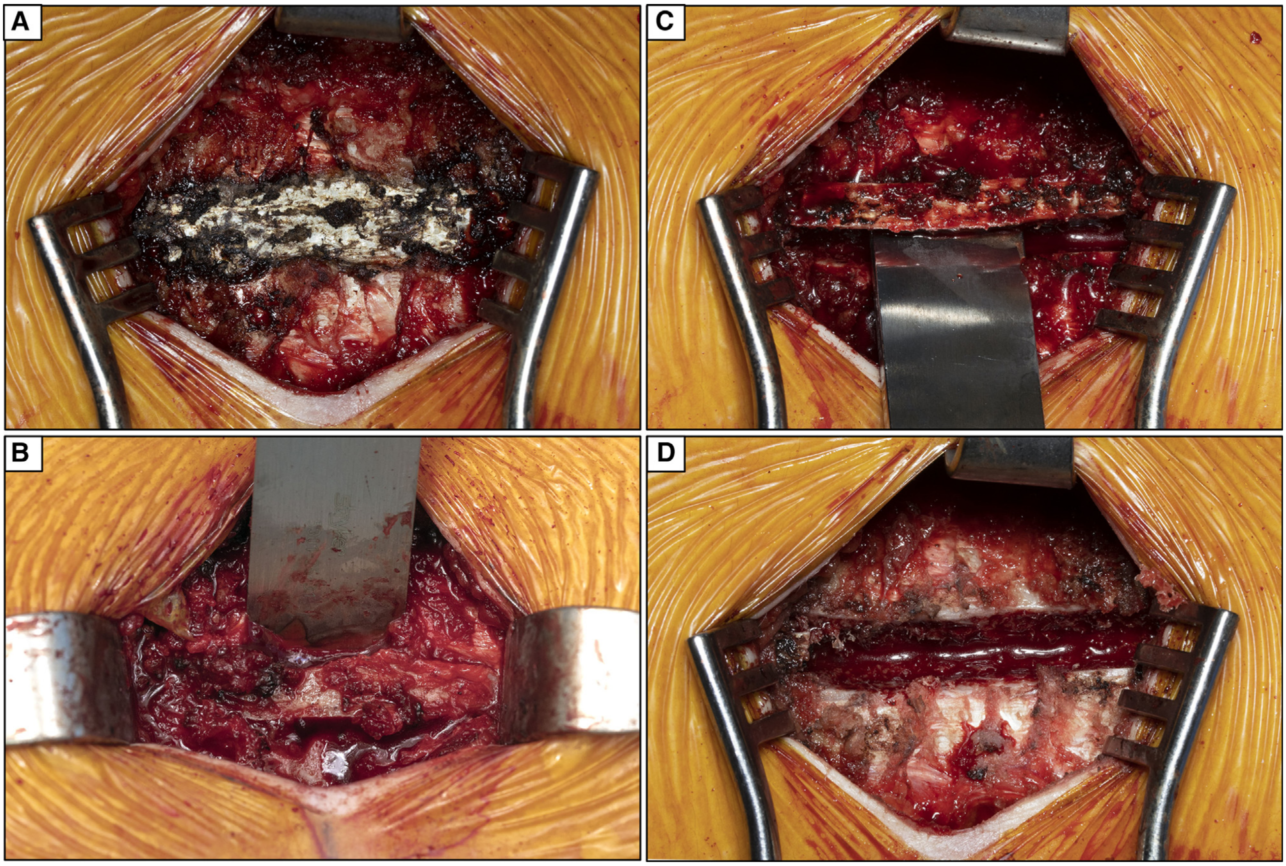


FIGURE 3. A, Sternum marked for osteotomy. B and C, Wedge sternal cut using an oscillating saw followed by careful angulated alternating movements to loosen the pieces using an osteotome. D, Wedge cut preserving the posterior table.

tied with a loop around the more superior bar and sternum. This was done by drilling sternal holes and passing FiberWire under direct thoracoscopic visualization to encircle the sternum and bar. Medial stabilizers were also utilized since they became available in 2022 for all lower bars to help prevent rotation (Figure 4, *C*).

After elevation of the lower sternum, manual pressure was applied to reduce, approximate, and flatten the cut sternal edges (Figure 4, *A* and *B*). Different plating systems were used for stabilization. Recently, the ladder plate system predominated (Zimmer BioMet Inc), as evidenced by our experience and others (Figure 4, *D*).[24] FiberWire ties were circumfertially placed around the plate and sternum for added security.

After sternal fixation, adjacent ribs were assessed for reattachment. More often, there was abnormal, redundant cartilage requiring resection. It is important to remove minimal cartilage and err on needing more than risking overresection. The ideal technique is to separate and preserve the perichondrium and peel out the underlying cartilage segment. However, most patients had calcified cartilage hindering separation. An osteotome or sometimes an oscillating saw was required to cut few millimeters from the rib end and attempt approximation to the sternum. Incrementally cutting 1 to 2 mm creates the best angle and approximation (Figure 2). For persistent lateral rib tension or medial elevation, a relaxation cut could be made at the highest point of elevation through the anterior cortex of the rib (Figure 2). All adjacent ribs were initially approximated to the sternum using a heavy 0 or #1 Vicryl suture (Ethicon Inc). Based on the stability of this approximation, more permanent stabilization could be added. FiberWire suture and titanium plating were the most utilized methods for additional fixation. Because plating will be at least partially on cartilage, it is important to use a screw length that will completely transverse the rib. A minimum of four screws should be embedded in the ribs and 4 screws in the sternum, as illustrated in Figure 2. FiberWire can also be wrapped circumferentially around the rib and plate to add to plate fixation. A detailed video of the hybrid surgical approach for pectus arcuatum repair has been provided (Video 1).

Over the years, various pain control methods were utilized, including patient-controlled intravenous analgesia, subcutaneous pain catheter, and intercostal nerve cryoablation, as described in our prior publications.[25,26] A TEE was repeated for confirmation and comparison with the baseline results. A 16 Fr chest tube was left in all cases through the right inferior port and in some cases, a drain was placed at sternal site. The muscles, subcutaneous tissues, and incisions were closed in layers with Vicryl absorbable sutures. Sterile dressings were applied, and the chest tube was connected to suction.

RESULTS

Twenty pectus arcuatum repairs were done during the study period. The median age was 22.9 years (range, 13-58 years). Table 1 reviews the patient demographics. Preoperatively, all patients were bothered by their chest appearance and symptomatic, with the most common symptoms being exercise intolerance (95.0%), chest pain (90.0%), and shortness of breath (90.0%). Among the patients who underwent PFT, 38.5% had mildly restrictive patterns. Almost half the patients underwent CPET, with a median maximum oxygen consumption of

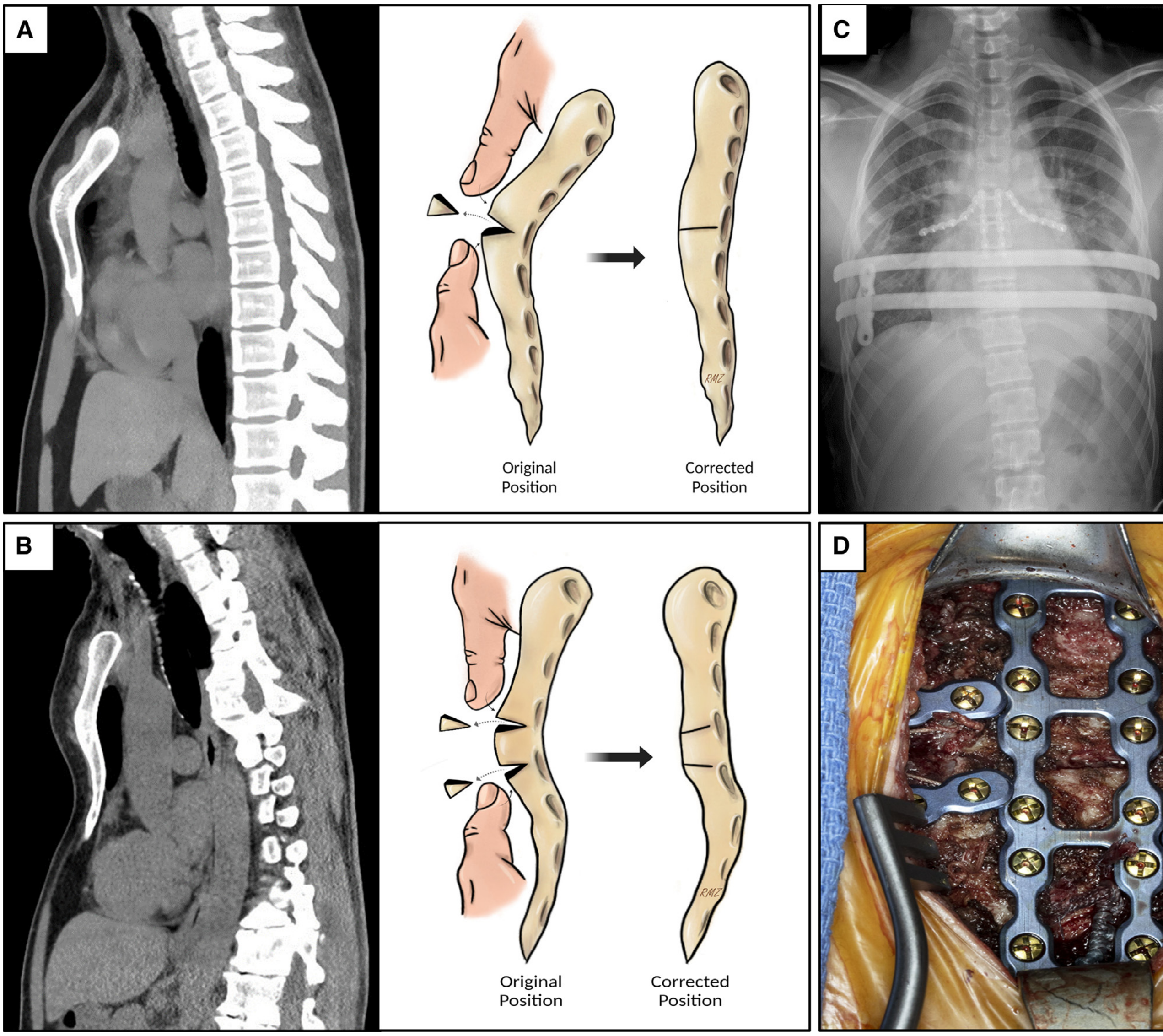


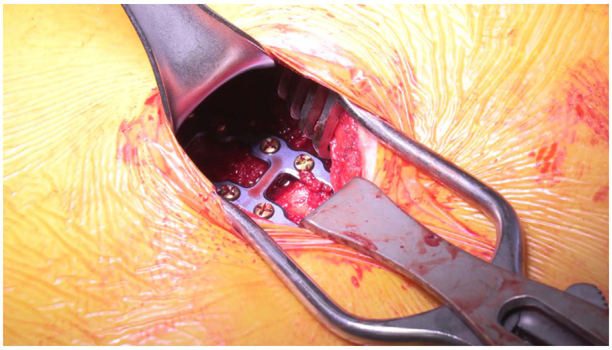
FIGURE 4. A and B, Preoperative computed tomography scans highlight sternum elevation sites, aiding in planning osteotomies. A "*V*" cut through the sternal anterior table facilitates flattening and stabilization with plating. C, Chest radiograph showing plating and Nuss bars with medial stabilizer. D, Intraoperative image of sternal and adjacent rib plating.

67.0% (IQR, 57.3, 69.0%) of predicted value. Variable electrocardiogram changes and a significant drop in the right ventricular outflow tract velocity-time integral (RVOT-VTI) with positional changes was noted in our cohort (RVOT-VTI 15.5 cm (IQR, 14.2, 19.0 cm) in the supine position versus 11.9 cm (IQR, 9.1, 15.1 cm) when sitting and leaning forward; $P = .005$).

The hybrid minimally invasive repair approach was successfully performed in all patients, with an average intraoperative time of 3.5 hours (IQR, 3.1, 4.2 hours) and minimal blood loss (median, 100.0 mL; IQR, 50.0, 200.0 mL). Single wedge osteotomy was sufficient in most cases (70.0%). Two bars were placed in 14 cases (70.0%) (Table 2).

The adoption of cryoablation in 2018 has led to a notable reduction in hospital stays from 5.0 days (4.5, 6.0 days) to 3.0 days (2.8, 5.0 days) ($P < .001$). During the hospital stay, one patient developed left hemothorax requiring pigtail insertion and blood transfusion. No other major complication was documented. Within the first 30 days postdischarge, 3 patients required thoracentesis. One patient, with history of postsurgical deep vein thrombosis, developed deep vein thrombosis and was started on anticoagulation therapy. Another patient developed hardware infection managed with chronic antibiotic supression (Table 2).

Follow-up was present in all patients, with 80.0% having more than 6-months' follow-up (median, 2.9 years; IQR,



VIDEO 1. Detailed hybrid surgical approach for pectus arcuatum repair. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00424-3/fulltext.

0.9, 4.9 years). All patients reported improvement in preoperative symptoms and exercise tolerance except for 1, and all noted satisfaction with the cosmetic outcomes. No patient required reintervention for bar migration; however, 1 patient had plate elevation that required removal after 10 months. Nearly half the patients (9 out of 20) underwent bar removal (median, 3.0 years; IQR, 2.7, 3.6 years postinsertion), with a median follow-up time of 1.5 years (IQR, 0.1, 5.5 years) postbar removal. Among them, all patients but 1 patient reported no signifcant pain. The patient who reported persistent pain had a history of chronic pain syndrome and was also the same patient who required FiberWire removal. No patients reported regression (Table 2).

DISCUSSION

Pectus arcuatum is a rare chest wall deformity frequently misdiagnosed and misunderstood. The low associated Haller index, often below the 3.25 standard cutoff for a severe pectus deformity, adds to the misconception that the deformity is merely a cosmetic issue.[9,12] Given the unremarkable Haller index, it is increasingly challenging to obtain approval for repair solely based on cosmetic reasons, highlighting the importance of describing the potential cardiopulmonary effects. The manubriosternal joint calcified fusion with the subsequent lower sternal angulation and rigid fixation creates an unyielding external pressure point into the underlying intrathoracic structures. The sternum is shortened, and the associated costal cartilages are often crowded and collapsed inward at the caudal aspect where the sternum is missing (Figure 5, *A*). This may be less apparent in supine position and could be overlooked on imaging like CT or standard echocardiography, usually done in supine position. When the patient sits up and leans forward, lower cartilages deviate inward and may compress into the right cardiac chambers (Figure 5, *E* and *F*). A positional echocardiogram may be helpful in detecting this, especially when assessing the right ventricular outflow tract compression. A significant drop in the RVOT-VTI with positional changes should prompt evaluation for potential impactful external right heart compression (Figure 5).

TABLE 1. Demographics and preoperative assessment

Characteristic	Result
Total patients	20
Age (y)	22.9 (19.5, 34.3)
Male sex	11 (55.0)
Body mass index	21.9 (20.4, 24.9)
Preoperative Haller index	2.8 (2.2, 3.6)
Preoperative symptoms	
Cosmetic dissatisfaction	20 (100.0)
Exercise intolerance	19 (95.0)
Chest pain	18 (90.0)
Shortness of breath	18 (90.0)
Failure to keep up with peers	13 (65.0)
Palpitations	10 (50.0)
Dizziness	10 (50.0)
Extremity numbness	5 (25.0)
Associated disorders	
Anxiety	12 (60.0)
Major depressive disorder	7 (35.0)
Bipolar	1 (5.0)
Chronic pain syndrome	2 (10.0)
Scoliosis	6 (30.0)
Klinefelter syndrome	1 (5.0)
Family history of pectus	7 (38.9)*
Preoperative workup	
Electrocardiogram	20 (100.0)
Left-axis deviation	1 (5.0)
Right-axis deviation	1 (5.0)
T wave inversion in the anterior leads	1 (5.0)
Premature atrial complexes	1 (5.0)
Positional echocardiogram	18 (90.0)
RVOT-TVI baseline (cm)	15.5 (14.2, 19.0)
RVOT-TVI leaning forward (cm)	11.9 (9.1, 15.1)
RVOT-TVI <15 cm	7 (35.0)
Pulmonary function tests	13 (65.0)
FEV1 (L)	94.5 (79.8, 97.5)
FVC (L)	90.0 (76.0, 103.0)
FEV1/FVC	1.0 (0.9, 1.1)
Cardiopulmonary exercise testing	9 (45.0)
VO_2 max (%)	67.0 (57.3, 69.0)

Values are presented as median (interquartile range) or n (%). *RVOT-TVI*, Right ventricular outflow tract velocity-time integral; *FEV1*, forced expiratory volume; *FVC*, forced vital capacity; *VO_2 max*, maximal oxygen consumption. *Unknown family history in 2 patients, n = 16.

Subjective assessments, alongside objective measures, can elucidate the physiological effects of arcuatum deformities. In this cohort, all patients reported varying degrees and combinations of cardiopulmonary symptoms, which have also been highlighted by others.[5,15,27,28] Although most patients had normal pulmonary function, some restriction can be found, making testing worthwhile. In patients complaining of exercise intolerance, additional tests such as CPET may

TABLE 2. Operative and postoperative details

Detail	Result
Intraoperative time (h)	3.5 (3.1, 4.2)
No. of bars placed	
0 bars	1 (5.0)
1 bar	5 (25.0)
2 bars	14 (70.0)
Sternal osteotomy	
1 osteotomy	14 (70.0)
2 osteotomies	6 (30.0)
Sternal stabilization	
FiberWire	1 (5.0)
Titanium plating	19 (95.0)
Adjacent ribs osteotomies required	19 (95.0)
Rib osteotomies stabilization	
Suture or FiberWire* stabilization only	8 (42.1)
Titanium plating stabilization	11 (57.9)
Estimated blood loss (mL)	100.0 (50.0, 200.0)
Length of hospital stay (d)	3 (2.8, 5.0)
Major in-hospital postoperative complications	
Hemothorax requiring pigtail insertion and blood transfusion	1 (5.0)
Minor in-hospital postoperative complications	
Significant pain	6 (30.0)
Nausea and vomiting	2 (10.0)
Urinary retention requiring catheter insertion	3 (15.0)
Without acute kidney injury	2 (10.0)
With postrenal acute kidney injury	1 (5.0)
Delirium	1 (5.0)
Major 30-d postoperative complications	
Pleural effusion requiring thoracentesis	3 (15.0)
Minor 30-d postoperative complications	
Significant pain requiring emergency room visit	1 (5.0)
Hardware infection requiring chronic antibiotic suppression	1 (5.0)
Deep vein thrombosis	1 (5.0)
Bar complications	
Pain requiring FiberWire removal and bar tip bending	1 (5.0)
Bar rotation or posterior-lateral migration	0 (0)

*Arthrex Inc.

be warranted. Only 9 out of 20 patients underwent CPET, yet the median maximum oxygen consumption was significantly low at 67.0% predicted value. In this cohort, all but 1 patient experienced symptom improvement, validating the surgical management of arcuatum.[5,15,27,28]

This deformity is frequently misdiagnosed and mistreated due to shared features with other pectus deformities. One characteristic feature of arcuatum is the shortened, fixed, and rigidly deformed sternum, making minimally invasive repair alone insufficient. A sternal osteotomy is essential. Ravitch's successful arcuatum repair in 1952[5] and subsequent studies[3,29,30] recommended wedge sternal osteotomy for correcting sternal angulation. In our experience, multilevel sternal wedge osteotomy has not proven crucial or superior,[12,27,30] and only a "*V*" cut through the sternal anterior table was necessary.[2,3,15,29] Depending on sternal length and angulation severity, a single osteotomy was used in 70.0% of cases, with the rest requiring multiple osteotomies. Although nonabsorbable sutures[3,5] or wires[31,32] can stabilize the sternum, titanium plating is our preferred choice to prevent sternal malunion and reduce postoperative pain.[33,34] The elevated cartilages, typically affecting the second through fourth ribs, can pose challenges. For minor elevation, shaving is possible, but regrowth may occur. Although preserving the perichondrium is ideal for long-term cartilage integrity and regrowth facilitation,[9,27] it may not be feasible in older patients. A straightforward osteotomy may be necessary, followed by fixation to ensure proper healing to the sternum. Titanium plating was commonly used to stabilize these ribs; however, a drawback is the potential for screws to loosen. One patient required reoperation for this.

Although some have only performed a sternal osteotomy to repair arcuatum,[12-14] we recommend placing bars in every patient to address potential cardiac compression, especially given the inward concavity of the lower costosternal ribs. Early in our experience, we omitted using a Nuss bar in 1 patient, which was considered suboptimal despite rating outcomes as excellent in surveys. Unlike a standard Nuss procedure where bars are placed firmly beneath the sternum,[16] for arcuatum patients, the bars may be positioned at the distal end or inferior to the sternum due to its shortened nature. These bars not only elevate the depressed sternum but also aid in lifting, stabilizing, and assisting in the lower costal cartilage remodeling. The instability of bars in this position is greater and use of sternal ties, hammock stitches, medial stabilizers, lateral bridging devices, or other methods should be employed to secure them in place. Fonkalsurd and colleagues[27] emphasized that bars in arcuatum eradicates postoperative complications like flail chest and paradoxical breathing, lessens postoperative pain, promotes early ambulation, deeper respiration, and shorter hospital stays, resulting in cost savings. The timing for bar removal varies among surgeons, ranging from 6 months to 3 years.[16,27]

Limitations

Being a single-institution, single surgeon review, it has limitations inherent to retrospective studies, learning experiences, and potentially nonreplicable outcomes. The small sample limits comprehensive analysis; however, this is one of the largest arcuatum cohort ever reported. Additionally, the lack

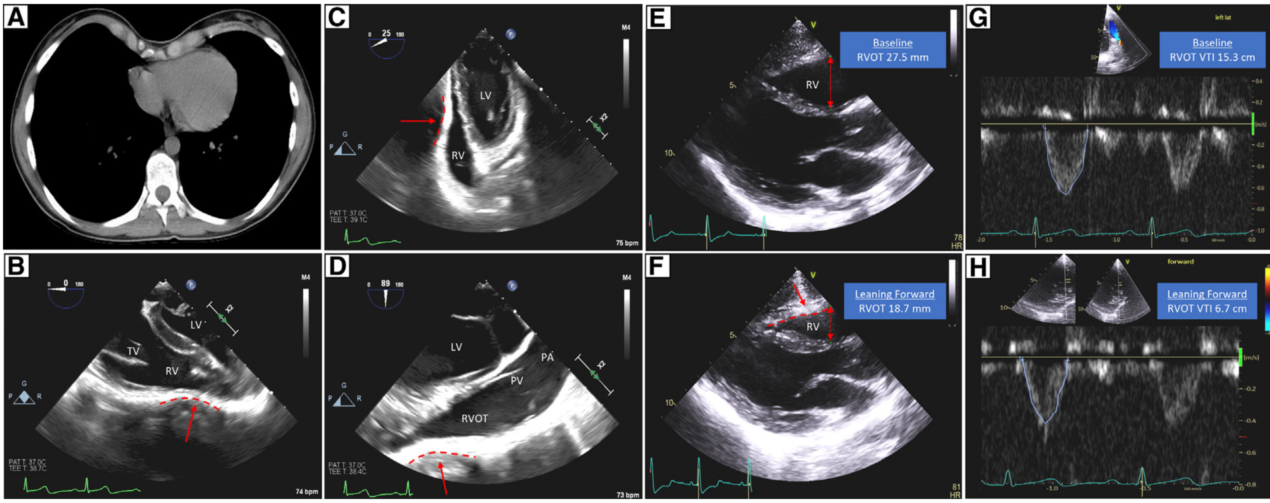


FIGURE 5. A, Axial computed tomography view showing external right heart compression by the lower costal cartilages. B-D. Intraoperative transesophageal echocardiography demonstrating significant external compression *(red arrows* and *dotted lines*) and right ventricle outflow tract (*RVOT*) diameter reduction. E, Preoperative transthoracic echocardiogram (TTE) image with the patient in the supine position showing minimal right ventricular compression (*red double sided arrow*). F, Preoperative TTE image with the patient leaning forward showing clear evidence of how the inward displacement of the lower costal cartilages causes an increased right ventricular cardiac compression *(red arrow* and *dotted line*) with decrease in the diameter of the RVOT (*red double sided arrow*). G, RVOT velocity-time integral estimated in the supine position, showing decreased right ventricle stroke volume due to external right heart compression. H, RVOT velocity-time integral estimated with the patients leaning forward revealing a more significant drop.

of literature on this topic raises concerns about inconsistencies in documenting older cases, further restricting our data. Positional hemodynamic changes have also been reported in 1 small size study of healthy population[35]; therefore, the inclusion of controls could have further validated this finding.

CONCLUSIONS

Pectus arcuatum is a rare, frequently misdiagnosed anatomical variant of pectus deformities that requires a hybrid approach for surgical repair. A sternal osteotomy is necessary for reduction of the calcified deformed sternum. Placement of Nuss bars is recommended to repair the excavatum component. Symptomatic patients should be considered for operative intervention and expected to improve after surgical repair.

Conflict of Interest Statement

Dr Jaroszewski has collected consulting and IP/royalties through Mayo Clinic Ventures with Zimmer Biomet Inc, and is a speaker with AtriCure Inc. All other authors reported no conflict of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflict of interest.

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Key Words: pectus arcuatum, Currarino-Silverman syndrome, Pouter pigeon breast, chondromanubrial deformity, type II pectus carinatum, horns of steer deformity, hybrid MIRPE