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CASE REPORT

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Concomitant Kommerell diverticulectomy, carotid-subclavian bypass, and modified ravitch pectus excavatum repair via sternotomy

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Abstract

Congenital heart disease may present with pectus excavatum. Concomitant and staged repair are described, but the optimal approach is controversial. We report a 17-year-old male with left aortic arch, aberrant right subclavian artery, and Kommerell diverticulum who presented with long standing swallowing difficulties, prandial nausea, and pectus excavatum with cosmetic concerns. Kommerell diverticulectomy, carotid-subclavian bypass, and modified Ravitch pectus excavatum repair were performed without complication. Concomitant congenital heart surgery and pectus excavatum repair may be successfully performed in a single operation via sternotomy. Incidence, operative approaches, and complications of concomitant versus staged correction of congenital heart disease and pectus excavatum are briefly reviewed.

Keywords Vascular ring, Aberrant subclavian, Kommerell diverticulum, Sternotomy, Pectus excavatum, Modified ravitch repair

Introduction

Pectus excavatum may accompany connective tissue disorders or congenital heart disease that require cardiac repair. In patients with congenital heart and chest wall defects, concomitant [1–9] versus staged [2, 3, 8, 10] approaches are debated.

We report a 17-year-old male who presented with a symptomatic aberrant right subclavian artery, Kommerell diverticulum, and pectus excavatum. Kommerell diverticulectomy, carotid-subclavian bypass, and modified Ravitch pectus excavatum repair were performed in a single operation via sternotomy without complication. Incidence, operative approaches, and complications of concomitant versus staged correction of congenital heart disease and pectus excavatum are briefly reviewed.

Case report

A 17-year-old male presented with pectus excavatum (Fig. 1A) and long-standing dysphagia and reflux since early adolescence. The patient reported low self-esteem from the appearance of his chest wall as well as prandial nausea and early morning cough and voice hoarseness. Omeprazole therapy failed. Upper endoscopy with

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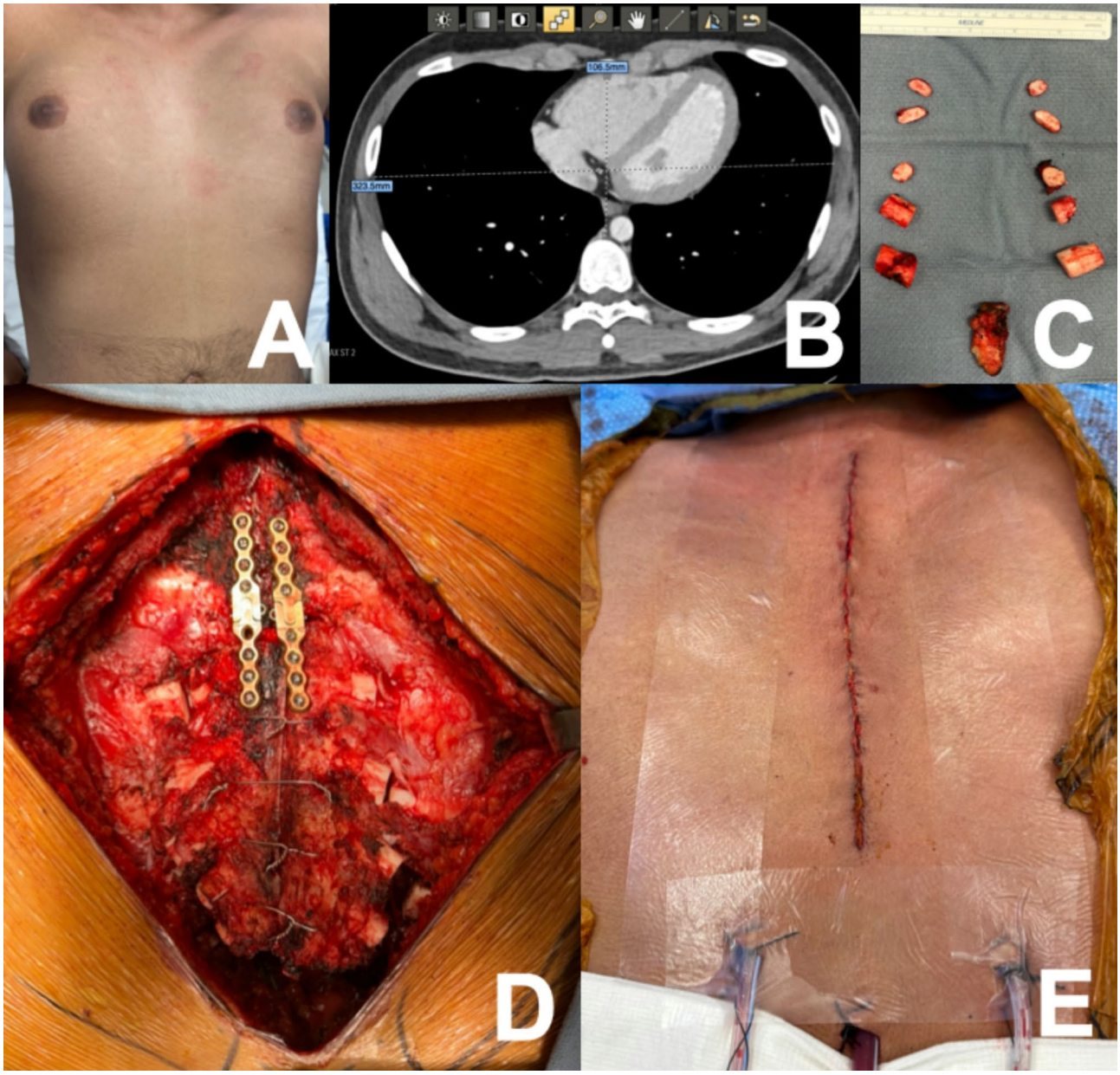

Fig. 1 A 17-year-old male presented with dysphagia and reflux. (**A**) Pectus excavatum caused psychosocial distress. (**B**) A Haller index of 3.0 was noted (measurements included). (**C**) Segments of costochondral cartilage 3 through 7 and the xiphoid process were removed to free the sternum from the ribcage. (**D**) After transverse osteotomy below the sternomanubrial joint, titanium plates and sternal wires were used to reposition the sternum anteriorly and fix the sternal edges. (**E**) The final result is shown

esophageal, gastric, and duodenal biopsy were unremarkable. Fluoroscopic barium esophagram demonstrated extrinsic posterior esophageal compression and proximally retained contrast. Chest computed tomography angiography (CTA) demonstrated a left aortic arch, aberrant right subclavian artery, and 16 mm Kommerell diverticulum compressing the esophagus (Fig. 2A, B). The right subclavian artery distal to Kommerell tapering was 9 mm. Symmetric pectus excavatum with a Haller index of 3.0 and mild right ventricular compression were noted (Fig. 1B). Transthoracic echocardiography confirmed mild apical right ventricular compression. Pulmonary function testing was unremarkable.

Operative indications and surgical approaches for dysphagia lusoria, Kommerell diverticulectomy, and pectus excavatum repair were discussed in detail with the patient and family. The indication for operation was a symptomatic aberrant subclavian with Kommerell diverticulum > 1.5x the diameter of the subclavian artery and pectus excavatum with psychosocial cosmetic concerns.

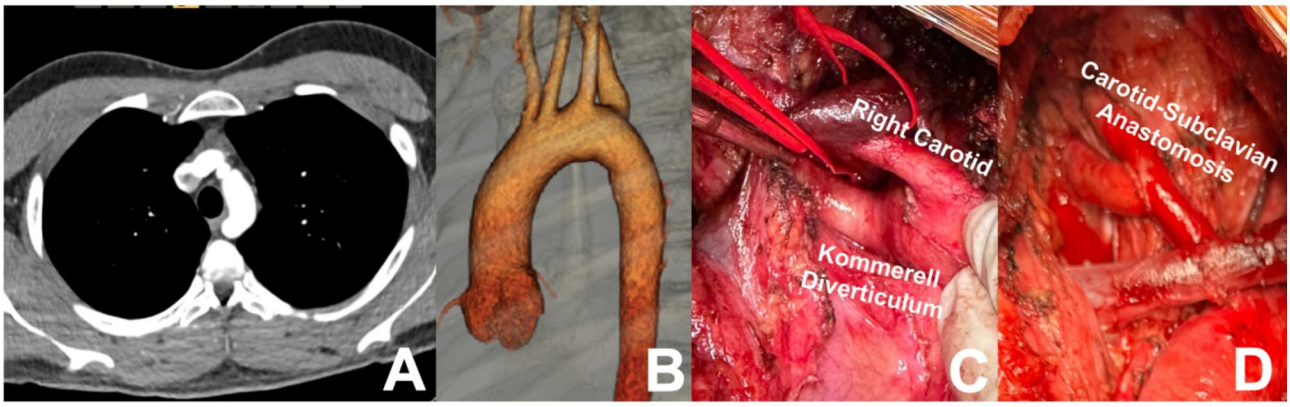

Fig. 2 (**A**) Computed tomography angiography demonstrated a left aortic arch, aberrant right subclavian artery, and 16 mm Kommerell diverticulum. (**B**) 3-D reconstruction demonstrateds an aberrant subclavian emerging from the posterior descending aortic arch and passing posterior to other arch vessels. (**C**) After release of circumferential attachments from the ascending aorta, transverse aortic arch, and aortic arch branches, leftward retraction of the aorta safely exposed the posteriorly located Kommerell diverticulum, which was resected. (**D**) Carotid-subclavian anastomosis was performed

Pros and cons and risks and benefits of sternotomy versus thoracotomy, modified Ravitch versus Nuss bar, and concomitant versus staged correction were presented. The family elected for Kommerell diverticulectomy, carotid-subclavian bypass, and concomitant modified Ravitch pectus excavatum repair via sternotomy.

In the operating room, central access was obtained via right internal jugular vein. Arterial blood pressure was monitored via left radial arterial line. Bilateral cranial near-infrared spectroscopy (NIRS) was monitored. An orogastric tube was placed to facilitate identification of the esophagus.

A standard midline sternotomy incision was made. Bilateral pectoralis flaps were created from xiphoid to sternomanubrial joint and midline to midclavicular lines. Rectus abdominis muscles were detached from the xiphoid and costal margins.

The aortic arch was prepared. Thymic tissue was largely removed to expose the aortic arch and great vessels. The superior pericardium was opened. The innominate vein, ascending aorta, extrapericardial aortic arch and branches, and proximal descending aorta were circumferentially freed of attachments. The left phrenic, vagus, and recurrent laryngeal nerves were identified and avoided. The origin of the Kommerell diverticulum and aberrant subclavian artery were carefully dissected from the esophagus and freed from surrounding attachments (Fig. 2C). Heparin (100 units/kg) was given. The aortic origin of the diverticulum was ligated at its base with 0 silk suture, transected, and oversewn with 5 – 0 Prolene suture. With gentle traction, the aberrant subclavian artery was removed from behind the esophagus. Aneurysmal Kommerell diverticulum tissue was resected.

The right common carotid artery was prepared for carotid-subclavian bypass. During test occlusion, NIRS were unchanged. Anastomosis of the right subclavian artery to the right common carotid artery was performed in end-to-side fashion with continuous, running 6 – 0 Prolene suture (Fig. 2D).

Attention was turned to the patient's chest wall. Moderate posterior deviation of the sternum was noted. The xiphoid process and short segments of costochondral cartilages 3 to 7 were bluntly excised with care to preserve posterior perichondrium and costochondral growth plates (Fig. 1C). To further free the sternum from the chest wall, bilateral intercostal muscles were partially detached. Alveolar tissue behind the sternum was bluntly dissected. During these maneuvers, care was taken to preserve both mammary arteries. A transverse osteotomy the thickness of two saw blades was made below the sternomanubrial joint with the oscillating saw. Sternal wires were placed in the manubrium and inferior two-thirds of the sternum. Two 10-hole titanium sternal plates were bent with appropriate angulation to fix the sternum anteriorly in the same plane as the manubrium (Fig. 1D). After fixation with self-securing screws, approximately 1.5 cm of space was created between the posterior sternum and right ventricle. The perichondrium at each level of cartilage resection was oversewn with 2 – 0 Vicryl ruffling stitches to tighten the interface between the intercostal muscles, opened perichondrium, and sternum. This tightened and appropriately contoured the chest wall for symmetry on either side of the anteriorly repositioned sternum. With these techniques, the sternum is maintained forward and a retrosternal Adkins strut and interval strut removal may be avoided [11]. For postoperative analgesia, intercostal nerve cryoablation and intercostal nerve block with liposomal bupivacaine were performed at ribs 2 through 7[12].

Preparations to close were made. Vancomycin paste was applied over sternal plates and wires. A 24 Blake drain was placed in the right lateral pericardium up to

the carotid-subclavian anastomosis. Two 15 Blake drains were placed anterior and posterior to the neosternum. Pectoralis flaps were secured in the midline, and rectus abdominis flaps were secured to inferior pectoralis fascia with 0 Vicryl suture. Absorbable suture closed remaining fascia, subcutaneous tissue, and skin in multiple layers. A negative-pressure wound dressing was applied.

Postoperative recovery was unremarkable. The patient was extubated in the operating room and discharged to home on postoperative day 5 without complication. Instructions for 2 months of strict sternal precautions and postural hygiene were given. At 6-weeks, the patient reported improved swallowing, resolution of prandial nausea and reflux, and improved body-self image. Patient and family consent were obtained for this case report.

Discussion

Kommerell diverticulectomy, carotid-subclavian bypass, and pectus excavatum repair may be performed safely and effectively in one operation via sternotomy without complication.

Pectus defects are a common congenital deformity characterized by a depression of the sternum and costal cartilages. Pectus may be present in as many as 0.2% of patients undergoing congenital cardiac surgery [2]. After congenital heart surgery, postoperative pectus that requires intervention develops in 0.5% of patients [10]. The optimal surgical approach to correct pectus excavatum with congenital heart disease is not established.

Surgical correction is considered based on several overlapping indications, which include: severe deformity with a Haller Index > 3.2, cardiopulmonary impairment from right ventricular compression, cardiac displacement, or restrictive pulmonary mechanics with dyspnea and exercise intolerance, chest musculoskeletal pain, psychosocial impact on self-esteem and cosmesis, failed non-surgical treatments, progressive deformity, and as in this case associated conditions. Of these, cosmesis is the most common indication for pectus repair [12]. Surgical pectus repair clearly imparts significant self-esteem improvement in the majority of postoperative patients [12, 13] and was observed in our patient.

The absolute indication for an operation in our patient was the symptomatic aberrant subclavian artery. The patient also expressed cosmetic concerns and low self-esteem associated with his chest wall defect. The indication for concomitant pectus repair was cosmesis. Mild right ventricular compression and a Haller index of 3.0 were also considered relative indications.

The patient and family preferred a single stage operation in which both defects were repaired rather than staged operations. Patient choice of surgical approach is an important consideration when repairing chest wall defects [14].

Pectus excavatum may be repaired via modified Ravitch repair or Nuss bar placement. Risks, benefits, and outcomes of each approach are well established [15]. However, in patients with pectus excavatum that require congenital heart surgery, risks and benefits of concomitant [1–9] versus staged [2, 3, 8, 10] approaches are debated.

Potential benefits of a single operation are relief of cardiac compression and distortion in the postoperative period with improved hemodynamics, avoidance of risks of redo surgery, single hospital stay, and reduced financial costs [8, 16]. Potential risks are prolonged operative time, higher rates of chest wall bleeding, transfusion, reoperation, infection, and malunion [1, 5, 8, 9]. Nevertheless, recent reports have advocated strongly for a single combined operation over staged operations [5, 8, 9].

Potential benefits of staged operations are reduced bleeding, transfusion, and reoperation, and increased chest wall pliability and pulmonary function after Nuss repair [8, 17]. Potential risks include inadequate exposure for cardiac surgery, impaired postoperative cardiac performance from unrelieved cardiac distortion, traction injury in the second operation from adhesions between the heart and sternum, and risks inherent in redo operations [1, 5, 8, 16]. Some of these risks may be mitigated by pericardial closure or placement of a pericardial barrier membrane in the first operation [8].

Kommerell diverticulectomy may be performed via multiple approaches [18]. The most common approach is thoracotomy. In infants and adolescents, we have preferred sternotomy to provide adequate exposure for safe diverticulectomy and subclavian reimplantation irrespective of arch sidedness. Circumferential release of attachments to the ascending aorta and arch branches allows lateral retraction of the aortic arch to safely expose the posteriorly located diverticulum (Fig. 2C).

We routinely perform intercostal nerve cryoablation [19] and intercostal nerve block for postoperative analgesia during modified Ravitch or Nuss bar pectus excavatum repair. With this approach, patients may be extubated in the operating room and typically spend two nights in the hospital with reduced need for narcotic pain medicine.

Conclusions

Concomitant correction of congenital heart disease and pectus excavatum may avoid risks of multiple operations and achieve a satisfactory outcome.

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Author contributions
CRB, SP, VM, and DM participated in preoperative workup, perioperative care, operative repair, and postoperative follow up of the patient. SP, VM, and DM

participated in literature review. CRB prepared the manuscript. CRB, SP, VM, and DM reviewed and edited the manuscript.

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No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
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Competing interests
The authors declare no competing interests.

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