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CASE REPORT

ADVANCED

CLINICAL CASE

Chest Pain and Dyspnea After a Minimally Invasive Repair of Pectus Excavatum

Juan M. Farina, MD,[a] Michael B. Gotway, MD,[b] Carolyn M. Larsen, MD,[c] Jesse Lackey, CSFA,[a] Kristen A. Sell-Dottin, MD,[a] Steven T. Morozowich, DO,[d] Dawn E. Jaroszewski, MD, MBA[a]

ABSTRACT

Although infrequent, damage to cardiovascular structures can occur during or following a minimally invasive repair of pectus excavatum. We present a case of right ventricular outflow tract compression caused by a displaced intrathoracic bar. Removal of the bar resulted in an improvement in symptoms and hemodynamics. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2022;4:476–480) © 2022 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

An otherwise healthy 41-year-old male patient with pectus excavatum (PEx) presented for a second opinion regarding persistent postoperative chest pain, exertional dyspnea, and palpitations following minimally invasive repair of PEx (MIRPE). Although some symptoms, particularly exertional dyspnea and palpitations, had been present before the repair, these had progressively worsened after the surgical procedure.

LEARNING OBJECTIVES

- To recognize the cardiovascular implications of PEx and its repair.
- To review the importance of cardiovascular imaging when addressing this chest wall defect.

PAST MEDICAL HISTORY

The patient had undergone MIRPE at an outside institution with placement of 2 intrathoracic bars 6 months previously. One month following surgery, because of the persistence of symptoms, enhanced chest computed tomography (CT) was performed. The CT scan showed that the 2 bars, particularly the inferior bar, had migrated posteriorly as a result of lateral stripping (**Figure 1**). Immediately following this CT scan, the lower bar was removed.

DIFFERENTIAL DIAGNOSIS

At the time of presentation to our hospital (Mayo Clinic), the patient had a single intrathoracic bar. The differential diagnosis of the patient's persistent symptoms included residual cardiac compression by

From the [a]Department of Cardiovascular and Thoracic Surgery, Mayo Clinic, Phoenix, Arizona, USA; [b]Department of Radiology, Mayo Clinic, Phoenix, Arizona, USA; [c]Department of Cardiovascular Medicine, Mayo Clinic, Phoenix, Arizona, USA; and the [d]Division of Cardiovascular and Thoracic Anesthesiology, Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, Phoenix, Arizona, USA.

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the unresolved PEx defect and cardiovascular compression from the remaining bar.

INVESTIGATIONS

Before his visit, the patient had undergone an outside transthoracic echocardiogram (TTE) that did not show any evidence of cardiovascular compression by the remaining bar, although the transthoracic acoustic window was limited. Diagnostic evaluation at our institution included chest radiography, which showed displacement of the left side of the intrathoracic bar (**Figure 2**). Given the concerning findings seen on the previous chest CT and the patient's significant symptoms, transesophageal echocardiography (TEE) was performed to evaluate for possible cardiac compression. This imaging revealed significant extrinsic compression of the right ventricular outflow tract (RVOT) by the displaced bar (**Figures 3A and 4A,** Video 1).

MANAGEMENT

The RVOT compression induced by the bar prompted immediate surgical removal. Because of the risks for potential damage to cardiovascular structures during the bar extraction procedure, the decision was made to have cardiovascular surgery and a cardiopulmonary bypass machine available. Intraoperative TEE was conducted throughout the bar removal process and showed no adverse hemodynamic changes, no evidence of pericardial effusion, and relief of the RVOT compression after bar removal (**Figures 3B and 4B**).

DISCUSSION

The external compression of cardiovascular structures caused by the depression of the anterior chest wall in PEx has been associated with cardiovascular deficits.[1] The most common procedure for the surgical repair of this defect is MIRPE, in which metal bars are placed posterior to the sternum to elevate the anterior chest wall; typically, these bars should be removed after 3 to 3.5 years.[2] This technique has demonstrated optimal cosmetic results, cardiopulmonary benefits, and a very low incidence of severe complications in experienced hands.[1-3] The

ABBREVIATIONS AND ACRONYMS

CT = computed tomography

MIRPE = minimally invasive repair of pectus excavatum

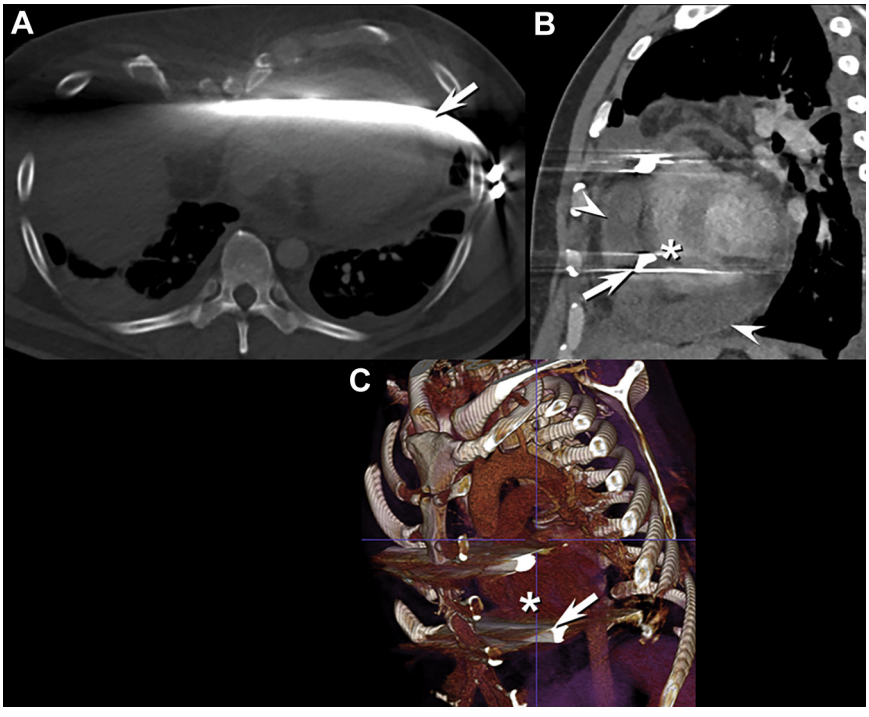
PEx = pectus excavatum

RVOT = right ventricular outflow tract

TEE = transesophageal echocardiography

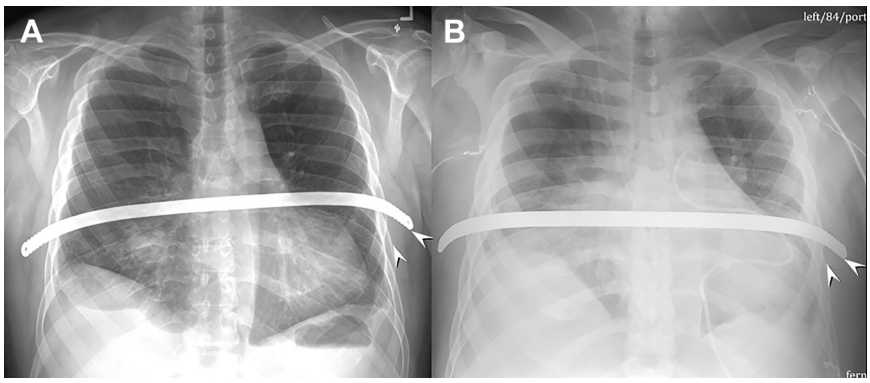
TTE = transthoracic echocardiography

FIGURE 1 Chest Computed Tomography Before Removal of Lower Pectus Bar



(A) Axial, **(B)** sagittal, and **(C)** volume-rendered enhanced computed tomography images show the 2 pectus bars, particularly the inferior bar **(arrow),** in contact with the right ventricular free wall (**asterisk**, right ventricular cavity). A moderate pericardial effusion **(arrowheads)** is present. The more cranially located bar is in contact with the anterior wall of the right ventricular outflow tract.

FIGURE 2 Chest Radiography at Presentation and 6 Months Earlier (Immediately Following the First Bar Removal Procedure)



(A) Frontal chest radiography shows a slight change in the orientation of the remaining bar; note how the lateral portion of the bar is more cranially angulated than **(B)** a radiograph obtained 6 months earlier. Also note a slight increase in the distance between the left lateral margin of the bar and adjacent rib **(arrowheads)** on **(A)** (measured at 18 mm) compared with **(B)** (measured at 14 mm).

surgical procedure requires a learning curve, and in older patients whose chest wall may be more rigid, a higher rate of displacement and complications is reported.[2] Although damage to cardiovascular structures by displaced bars is extremely rare (incidence <1%), such complications can be life-threatening.[3,4]

The close anatomical relationship between the anterior chest wall and cardiovascular structures must be recognized when addressing this disorder. A detailed preoperative evaluation should be performed to detect cardiopulmonary deficits related to PEx, including cardiopulmonary exercise testing, pulmonary function tests, and echocardiography. Surgical intervention should be performed only at experienced centers to minimize patient risks both at the time of the initial operation and postoperatively. In this case, the patient was functionally incapacitated over a period of 6 months because of critical cardiac compression from bar displacement.

For patients with unresolved symptoms during postoperative follow-up, bar displacement should be suspected, and multidisciplinary collaboration with surgeons, radiologists, and cardiologists is vital for accurate diagnosis. Chest imaging is critical to identify the presence and severity of displacement, the location of cardiac compression, and potential functional implications. In this regard, the multiplanar imaging capability of CT offers advantages when assessing bar position. With respect to echocardiography, TTE performed before bar removal in our patient failed to detect the extent of cardiovascular compromise from the displaced bar secondary to a limited transthoracic acoustic window. It is not uncommon that the leftward displacement of the heart from the PEx deformity and the presence of intrathoracic metal bars may result in substantial challenges when assessing for the cardiac consequences of PEx with TTE. Therefore, TEE is often required for the optimal evaluation of cardiovascular compromise.

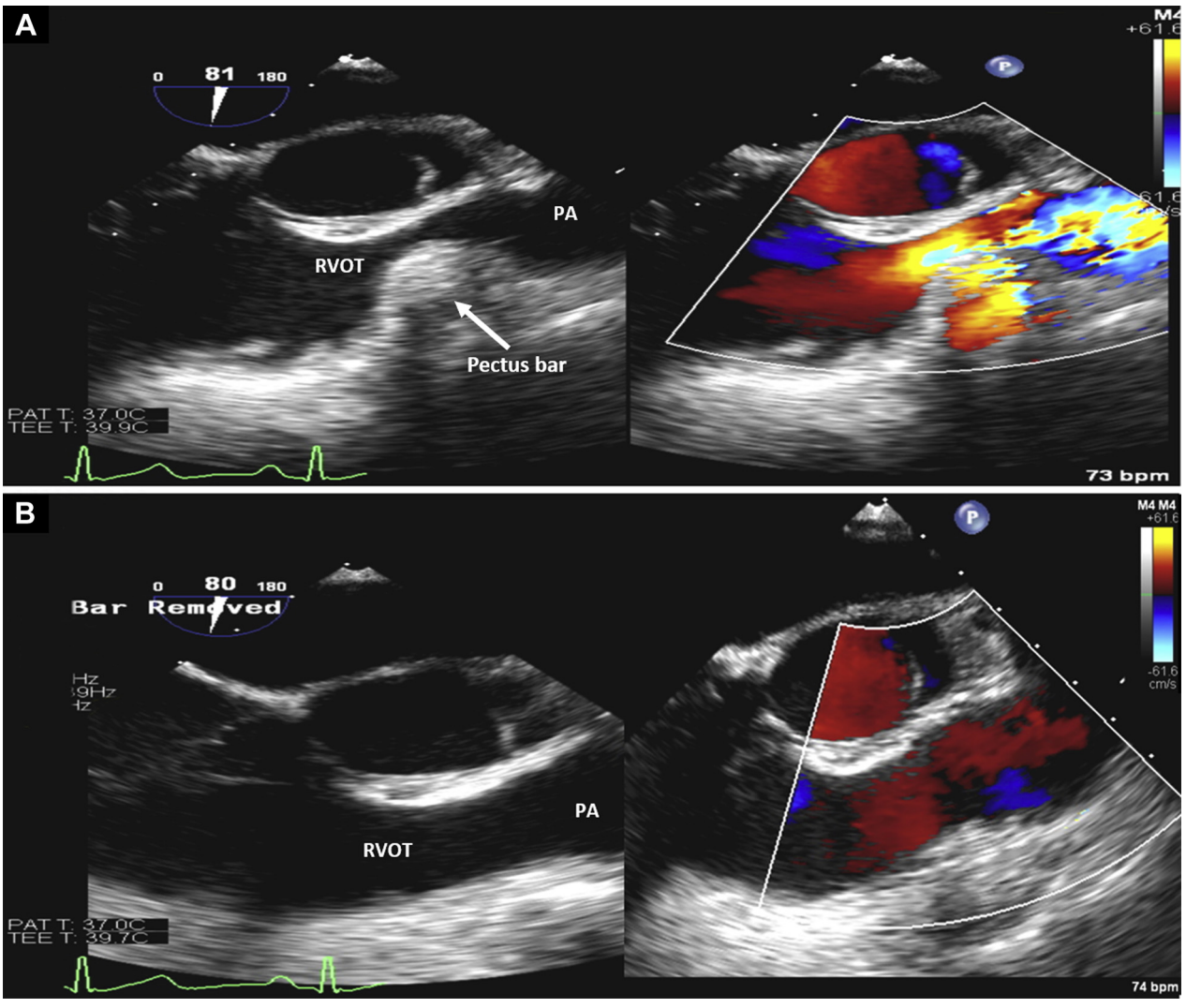
Currently there is no clear consensus regarding echocardiographic criteria for assessing RVOT obstruction severity, and because the symptoms are often worsened with exertion, clinical correlation is necessary.[5] In our patient, intraoperative TEE demonstrated RVOT obstruction resulting from external compression, the presence of turbulent flow, and elevated Doppler velocities, all of which resolved following surgery.

Detection of compression of cardiovascular structures by displaced pectus bars should prompt immediate bar removal. To minimize the risk of complications during the removal procedure, the use of intraoperative TEE should be considered. Cardiopulmonary bypass should be available for all cases in which a displaced bar causes significant compromise of cardiac structures.

FOLLOW-UP

The day after the bar removal procedure, the patient was discharged home without further issues. At a postoperative follow-up visit 1 week later, the patient noted significant improvement in his breathing

FIGURE 3 **Transesophageal Echocardiography Before and After Bar Removal**



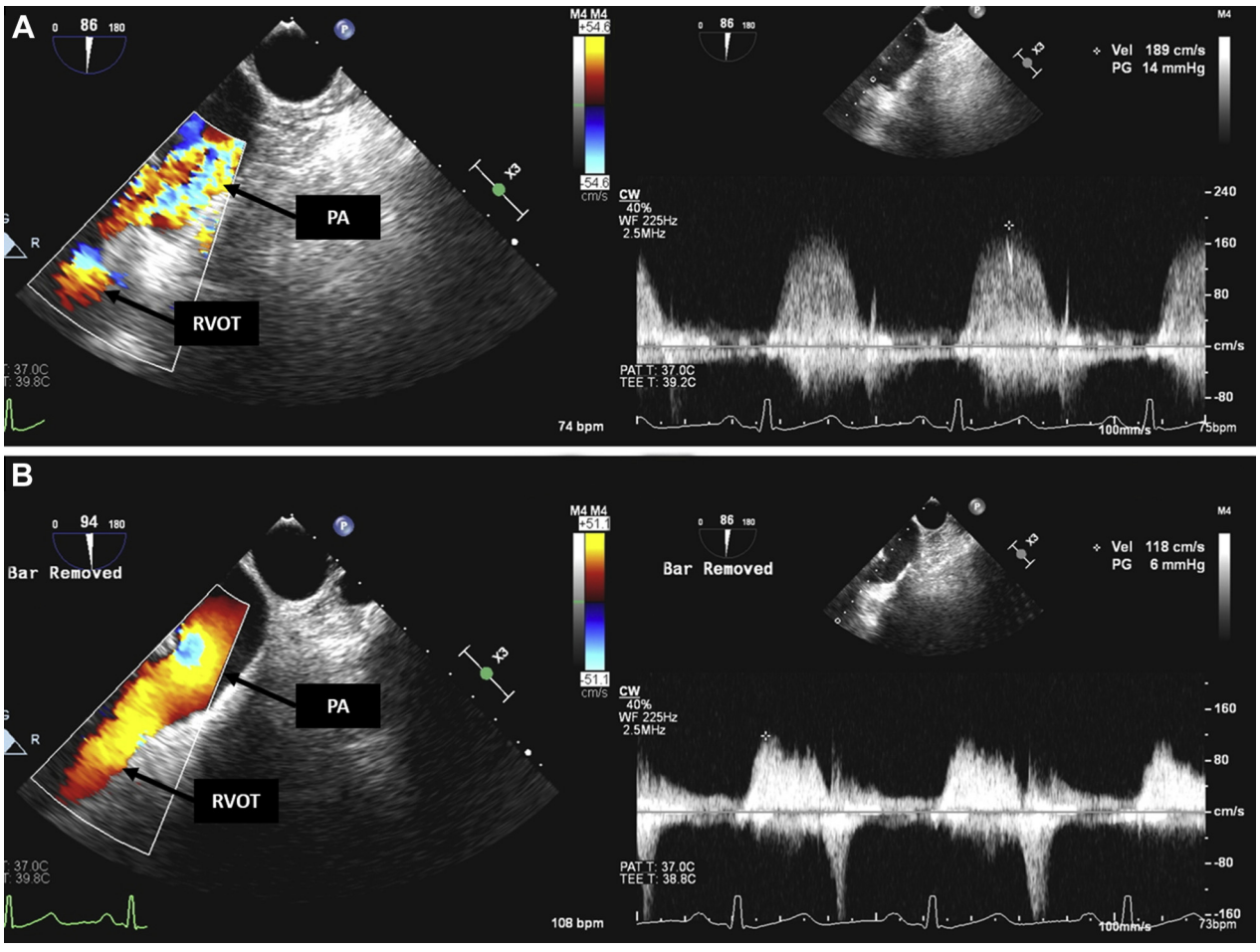
(A) Preoperative 2-dimensional midesophageal right ventricular inflow-outflow view showing severe compression of the right ventricular outflow tract (RVOT) by the displaced bar with turbulent color flow Doppler. **(B)** The 2-dimensional midesophageal right ventricular inflow-outflow view showing relief of RVOT obstruction and laminar flow after the bar removal procedure. PA = pulmonary artery.

capacity, and his chest pain had resolved. He is scheduled for revision repair of his residual PEx deformity in 6 months at our facility.

CONCLUSIONS

Cardiovascular impairment secondary to cardiac compression should be considered in patients with PEx, both preoperatively and during postoperative follow-up, particularly when new symptoms develop or previous symptoms worsen. Although infrequent, severe postoperative complications can occur, resulting from the close anatomical relationship between the anterior chest wall and the underlying cardiopulmonary structures. Patients under consideration for surgical repair should be referred to experienced centers to minimize risks. Close postoperative monitoring and chest imaging are crucial for the early identification of potential complications.

FIGURE 4 Preoperative and Postoperative Transesophageal Echocardiography



Upper esophageal aortic arch short-axis views showing the improvement from **(A)** turbulent to **(B)** laminar color flow Doppler images after bar removal. The corresponding continuous-wave Doppler velocities were **(A)** 1.89 m/s in the preoperative study and **(B)** 1.18 m/s in the postoperative study. Abbreviations as in Figure 3.

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Dr Jaroszewski has served as a consultant for Zimmer Biomet, Inc; and has received IP/royalty rights under Mayo Clinic Ventures with Zimmer Biomet, Inc. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr Dawn E. Jaroszewski, Department of Cardiovascular and Thoracic Surgery, Mayo Clinic, 5777 East Mayo Boulevard, Phoenix, Arizona 85054, USA. E-mail: jaroszewski.dawn@mayo.edu.

REFERENCES

1. Jaroszewski DE, Velazco CS, Pulivarthi VSKK, Arsanjani R, Obermeyer RJ. Cardiopulmonary function in thoracic wall deformities: what do we really know? *Eur J Pediatr Surg*. 2018;28(4):327-346.

2. Jaroszewski DE, Ewais MM, Chao CJ, et al. Success of minimally invasive pectus excavatum procedures (modified Nuss) in adult patients (≥30 years). *Ann Thorac Surg*. 2016;102(3):993-1003.

3. Hebra A. Minor and major complications related to minimally invasive repair of pectus excavatum. *Eur J Pediatr Surg*. 2018;28(4):320-326.

4. Parrado R, Lee J, McMahon LE, et al. The use of cryoanalgesia in minimally invasive repair of pectus excavatum: lessons learned. *J Laparoendosc Adv Surg Tech A*. 2019;29(10):1244-1251.

5. Zeng YH, Calderone A, Rousseau-Saine N, et al. Right ventricular outflow tract obstruction in adults: a systematic review and meta-analysis. *CJC Open*. 2021;3(9):1153-1168.

KEY WORDS complication, computed tomography, echocardiography, right ventricle, thoracic

APPENDIX For a supplemental video, please see the online version of this paper.