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Nuss procedure in the adult population for correction of pectus excavatum

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ABSTRACT

Minimally invasive repair of pectus excavatum has been successfully modified for use in adult patients. Many patients present in adulthood with progression of symptoms as the chest wall becomes less compliant with age. A thorough workup is completed including echocardiogram and chest CT to evaluate for anatomic abnormalities. Cardiopulmonary exercise testing is done to quantify the physiologic impact. Modifications of the original Nuss procedure required to allow for successful adult repair include the use of forced sternal elevation, the use of multiple bars, medial bar fixation, and interspace support to prevent bar rotation and migration. Occasionally, fractures may occur that require an open procedure and osteotomy or cartilage resection and hybrid approach incorporating the principals of intrathoracic support and osteotomy with bar stabilization.

Introduction

Pediatric surgeons have established that children are not just small adults and require specialized training and techniques for treatment. Likewise, successful repair of adults with pectus excavatum (PE) requires modifications of Nuss' procedure that has been universally adopted as the standard of care for repair of children and adolescents.[1] The optimal surgical treatment of adult patients with PE has been controversial with some surgeons warning against a minimally invasive repair of pectus excavatum repair (MIRPE) in patients beyond adolescence.[2,3] Repair of adults is more difficult and has greater complications reported.[4–7] Successful repair can however be obtained with an MIRPE approach.[4,6,8–10] We present our technical modifications of MIRPE that have enabled safe, cosmetically and physiologically successful and durable repair in adults up to age 72 years.

Adult patient presentation

Pectus excavatum is reported in the pediatric literature to be four times more common in men than women.[11,12] Similarly, surgical series of adults also report a higher frequency of men versus women undergoing surgical repair.[6,8,13] There may be, however, a large number of underdiagnosed or misdiagnosed females as breast tissue or breast implant augmentation obscures the defect.[11,12] Additionally, some PE patients may not experience symptoms until they enter adulthood.[14,13] Adult patients may present with notable progression of symptoms with aging as the chest wall becomes less compliant and compensatory mechanisms decrease[13,15–17] (Fig. 1 a and b). In nearly half of adults studied by Kratgen et al. development of symptoms did not occur until patients were in their 30's- to 40's.[15] They also noted symptoms improved significantly after surgical repair.[15]

There are a number of studies evaluating the physiologic impact of PE in children during exercise,[18–20] but there are few reports that exclusively examine adult patients.[21–29] The inward projection of the chest wall results in a negative cardiopulmonary impact due to varying degrees of cardiac compression.[23,26] With significant compression of the right heart chambers, right heart filling and flows are reduced leading to decreased stroke volume and cardiac output[17,22,23,26] (Fig. 1 c and d). Surgical repair of the PE alleviates compression, allowing for an increase in right heart chamber size, flow velocities, and improved cardiac output[6,15,23,26,25] (Fig. 1 e–g). In 101 PE patients ≥30 years, a mean increase in right ventricular output by 65% was seen after MIRPE by one center utilizing intraoperative transesophageal echocardiogram.[6] Krueger et al. also noted significant improvement in both right and left ventricular outputs after open repair.[25] Speckle tracking strain has also been used to evaluate myocardial contractile function of the right and left ventricle in PE patients before and after repair.[23] In 165 adults, significant improvements in all except LV radial strain rate were demonstrated after MIRPE repair.[23]

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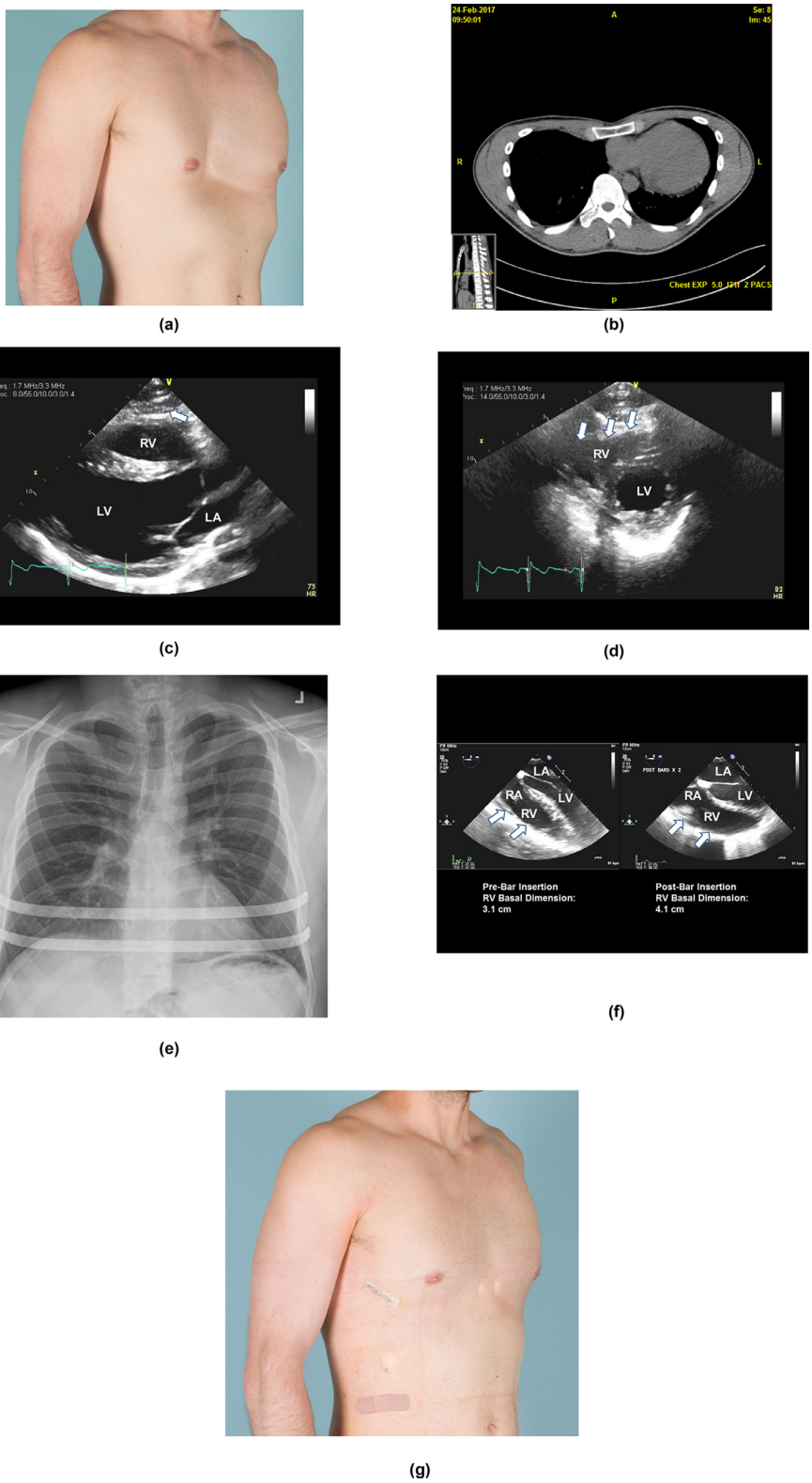

Fig. 1. a–g (a) Photograph of 30-year-old man with severe pectus excavatum which developed in his early teens. He noted significant progression of exertional dyspnea and tachycardia over the past 5 years. (b) Subsequent CT scan showed deformity causing cardiac compression and Haller index of 5. CPET testing showed significant decrease in exercise capacity with peak anaerobic VO_2 of 60% predicted. An echocardiogram was performed (c) Parasternal long-axis transthoracic view demonstrated basal to mid right ventricular external compression (white-arrow) due to pectus excavatum deformity (d) Parasternal short-axis transthoracic view demonstrating significant right ventricular external compression (white-arrows) due to pectus excavatum deformity. (e) An MIRPE with 2 bars was performed for PE correction (f) Four-chamber transesophageal echocardiogram imaging was performed during bar insertion. The pre-bar insertion images (left) demonstrated basal to mid right ventricular external compression due to pectus excavatum deformity (white-arrows) with basal right ventricular dimension measuring 3.1 cm. (Right) Following 2 bar insertion the right ventricular compression improved (white-arrows) and the basal right ventricular basal dimension increased to 4.1 cm. (g) Excellent cosmetic results and complete resolution of symptoms was obtained postoperative.