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A hybrid approach to maximize safety with thoracoscopic Nuss procedure after prior sternotomy

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ABSTRACT

The Nuss procedure for pectus excavatum repair in patients with history of sternotomies is technically challenging with the potential for serious complications including cardiac injury, which has been reported in 7% of cases. A pre-emptive redo sternotomy to free the mediastinum of adhesions and permit safe, unobstructed bar passage may mitigate this risk. Forced sternal elevation with sternal wires and the Rultract retractor creates additional space to achieve this. We advocate that this hybrid approach be standard of care to minimize intraoperative risks for this cohort of patients.

1. Introduction

The thoracoscopic Nuss procedure for repair of pectus excavatum (PE) after a previous sternotomy can be one of the most technically challenging and high-risk pectus repair procedures with the proximity of critical structures. Pectus surgery may occur several years following congenital heart surgery, with a different surgeon, who may not have access to prior records or be familiar with the chest closure technique or knowledge as to whether pericardium was closed, antiadhesives utilized, or a barrier placed. The incidence of acquired PE after congenital cardiac surgery has been reported as 0.53% [1]. Pediatric patients with congenital heart defects (CHD) often undergo multiple sternotomies that may contribute to an acquired PE that worsens with adolescent growth. The infrequency of these cases adds to the challenge for surgeons.

2. Case report and technique

Two patients at our institution underwent a modified minimally invasive Nuss procedure for PE following sternotomies for CHD in childhood. To maximize patient safety, we approached these cases with a planned redo sternotomy and cardiopulmonary bypass on standby. The first patient, with a medical history of Williams Syndrome, presented at 18 years old with two prior sternotomies and a left posterolateral thoracotomy for repair of long segment coarctation of the aorta. Pectus repair was recommended for significant cardiac compression (Fig. 1A) with increased right ventricle systolic pressures and decreased exercise capacity. The second patient presented at 14 years old with three prior sternotomies for subaortic stenosis resection over a period of 10 years. Repair was recommended for lack of endurance and exercise intolerance from cardiac compression (Fig. 1B).

A pre-emptive re-sternotomy was performed with careful dissection to free the right heart with opening and removal of wires. Adhesions in the mediastinum and to the lungs bilaterally were taken down. Once completely freed, a bovine pericardial patch

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(PhotoFix; CryoLife, Kennesaw, GA) was secured over the heart to create a barrier between the heart and the Nuss bars; two 6 × 8cm patches were sewn together with 4-0 Prolene. Prior to sternotomy closure, sternal osteotomies were performed with the sternal saw to angle the sternal edges to decrease the bevel (Fig. 2) and ensure approximation at the correct angle once the excavatum and sternum were elevated [2]. The sternotomy was closed in the usual fashion with wires, leaving 2 in the center uncut, to connect to the Rultract (Rultract, Cleveland, OH) retractor (Fig. 3). Subsequently, the Nuss procedure proceeded in the usual fashion with direct thoracoscopic visualization of insertion and passing of the bars across the mediastinum. The bars were secured with #5 Fiberwire [3] and bilateral chest tubes placed at the end of the procedure. Both patients received intercostal cryoablation for analgesia. One patient also had bilateral subcutaneous elastomeric pump infusion catheters (On-Q Pain Relief System; Avanos, Irvine, CA).

The patients were discharged on postoperative days 5 and 10 respectively. Neither required return to the operating room for bar migration or postoperative bleeding. In addition to cryoablation, postoperative analgesia was achieved with multimodal methods including patient-controlled analgesia, and oral analgesia, without significant challenges in pain control.

3. Discussion

Modifications to the standard thoracoscopic minimally invasive Nuss procedure have been described to accomplish PE repair safely after previous cardiac surgery. Techniques include a subxiphoid incision to facilitate blunt and sharp mediastinal dissection and sternal suspension with submuscular/subcutaneous bars [4–6]. In 2017, the Chest Wall International Group (CWIG) reported the experiences and techniques of 75 patients from 14 centers, with only a minority (7 patients) undergoing an elective sternotomy as part of their procedure. Five patients (7%) required a rescue sternotomy for cardiac injury with no ensuing deaths [7]. Although not included in this patient cohort, there is one reported death from right atrial perforation that occurred with mediastinal dissection through a subxiphoid incision during attempted pectus repair [8].

The risk of potential cardiac injury is significant during the Nuss procedure after a prior sternotomy [7]. This approach with planned redo sternotomy, takedown of mediastinal adhesions, followed by closure with a bovine pericardial patch increases safety and minimizes the need for rescue sternotomy and significant blood loss. At our institution, we changed the approach to pre-emptive median sternotomies to improve patient safety. This decision was made following a challenging thoracoscopic Nuss repair in a post-sternotomy patient with ventricular septal defect repair as an infant. Lysis of adhesions to free the pericardium from the sternum was performed under right thoracoscopic visualization. Even with sternal lift provided by the Rultract retractor, the working space was limited due to the PE defect and adhesions of the right heart to the sternum. While we were able to safely dissect the heart free and cross the mediastinum, we realized the significantly high risk of the procedure and moved towards ways to improve safety in future cases.

In the comprehensive experience described by the CWIG [7], 5 rescue sternotomies were performed during the Nuss procedure in patients with a history of sternotomies. In 4 cases, the cardiac injury occurred during mediastinal dissection due to adhesions from the right heart, usually the atrium. The remaining case was a right atrial laceration during blunt dissection. The pre-emptive sternotomy with lysis of adhesions addresses this challenge directly. Additionally, it allows quick access for control of bleeding and cardiopulmonary bypass initiation in case of injury during lysis of adhesions, compared to only using thoracoscopic blunt dissection of the mediastinum. Furthermore, our technique used sternal closure wires to achieve good sternal lift with the Rultract device. The additional space provides safe passage of the bars across the mediastinum and with direct thoracoscopic visualization during this process, there is no blind portion of the procedure.

Acknowledging adhesions that occur post-sternotomy, the pericardial patch is placed as an additional barrier between the heart and sternum to facilitate safe bar removal in the future. At this time, the two patients described have not presented for bar removal. In the CWIG patient series, 1/73 patients who underwent bar removal experienced bleeding from a cardiac laceration [7]. This patient had a history of a Mustard procedure for transposition in which the pericardium was not closed, but it is not stated if a pericardial patch was placed.

The inherent risks and challenges of a Nuss repair post-sternotomy have led some to advocate for the Ravitch procedure. A pre-emptive sternotomy and pericardial closure with a patch, as described with our technique, mitigates these issues, allowing for safe performance of a thoracoscopic Nuss procedure with preservation of the cartilage structure and flexibility of the anterior chest wall.

In the subset of patients with acquired PE following sternotomies for CHD, the potential for serious intraoperative complications during minimally invasive Nuss repair is significant. A hybrid approach with a pre-emptive sternotomy to free the mediastinum and

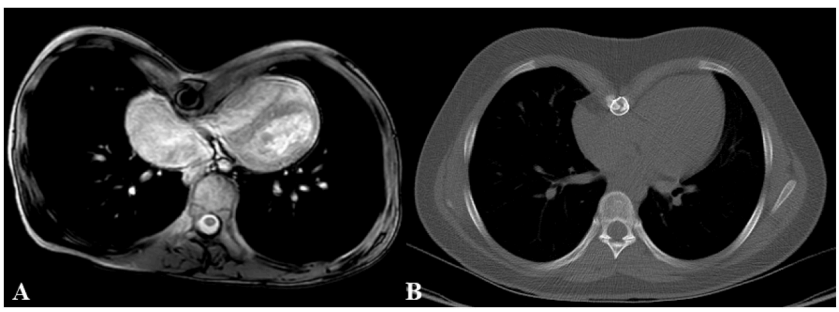

Fig. 1. Cross-sectional imaging demonstrating cardiac compression of patients 1 (A) and 2 (B).

Fig. 2. Sternal osteotomies prior to sternal closure to angle sternal edges and decrease bevel, allowing approximation once the excavatum and sternum are elevated.

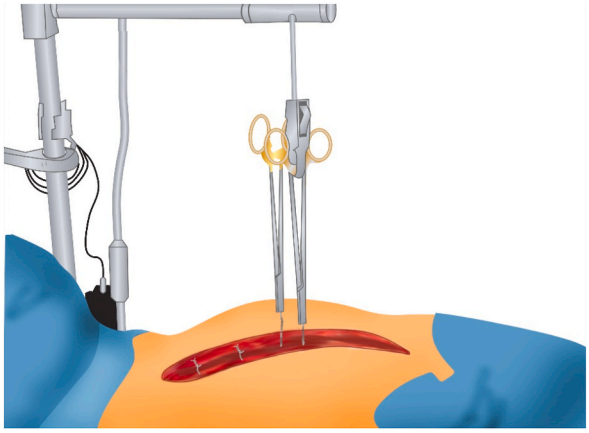

Fig. 3. Rultract retractor system providing sternal lift using uncut sternal wires.

permit safe, unobstructed passage of the bar is key to preventing cardiac injuries. We advocate that this become the standard of care for patients undergoing a Nuss procedure after previous sternotomy.

Patient consent

Consent to publish the case report was not obtained. This report does not contain any personal information that could lead to the identification of the patient.

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Authorship

All authors attest that they meet the current ICMJE criteria for Authorship.

Conflicts of interest

Dr. Jaroszewski discloses a financial relationship with Zimmer/Biomet Inc. through Mayo Clinic Ventures.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dawn E. Jaroszewski reports a relationship with Zimmer Biomet that includes: consulting or advisory.

References

[1] Li S, Tang ST, Tong Q, et al. Nuss repair of pectus excavatum after surgery for congenital heart disease: experience from a single institution. J Thorac Cardiovasc Surg 2014;148(2):657–61.
[2] Jaroszewski D, Eldeib A, Gotimukul A, et al. Cardiac transplantation and consecutive minimally invasive pectus excavatum repair. Ann Thorac Surg 2021;111(1):e11–4.
[3] McMahon LE, Johnson KN, Jaroszewski DE, et al. Experience with FiberWire for pectus bar attachment. J Pediatr Surg 2014;49(8):1259–63.
[4] Li S, Yang D, Ma Y, et al. Hybrid Nuss procedure for pectus excavatum with severe retrosternal adhesions after sternotomy. Ann Thorac Surg 2017;103(5):1573–7.
[5] Chen C, Li X, Zhang N, et al. Different Nuss procedures and risk management for pectus excavatum after surgery for congenital heart disease. J Pediatr Surg 2018;53(10):1964–9.
[6] Liu S, Wang L, Zhang H, et al. Modified Nuss procedure with a novel steel bar in patients with pectus excavatum post-congenital heart surgery [published online ahead of print, 2021 Oct 18]. Interact Cardiovasc Thorac Surg 2021. ivab284.
[7] Jaroszewski DE, Gustin PJ, Haecker FM, et al. Pectus excavatum repair after sternotomy: the Chest Wall International Group experience with substernal Nuss bars. Eur J Cardio Thorac Surg 2017;52(4):710–7.
[8] Zhang DK, Tang JM, Ben XS, et al. Surgical correction of 639 pectus excavatum cases via the Nuss procedure. J Thorac Dis 2015;7(9):1595–605.