The Nuss procedure for pectus excavatum during atrial septal defect closure through a minimal right oblique infra-axillary thoracotomy
A case report

Guangxian Yang, MD\textsuperscript{a,b}, Xicheng Deng, MD\textsuperscript{b}, Yifeng Yang, PhD\textsuperscript{a,*}, Jinhua Wang, MD\textsuperscript{b}

Abstract

Rationale: Pectus excavatum (PE) is normally an isolated congenital disorder, but it can also occur with congenital heart defect (CHD). The optimal strategy for the management of children with PE and concurrent CHD remains under debate. The surgical strategy has evolved over the last 20 years from staged repair to simultaneous repair of both defects. We present a case of using the Nuss procedure for PE during atrial septal defect (ASD) closure through a minimal right oblique infra-axillary thoracotomy. To our knowledge, this is the first report to describe the correction of PE and CHD by this approach.

Patient concerns: A 3.6-year-old patient weighing 13 kg was admitted for elective repair of PE and an ASD.

Diagnoses: Clinically, the patient had typical features of PE with chest computed tomography (CT) revealing a Haller index of 4.4 and a grade 2 systolic murmur being heard the loudest at the 2nd–3rd intercostal space, abutting the left sternal border. Echocardiography confirmed a 2-hole secundum ASD with the upper defect being 8 mm, the lower defect 5 mm, and the 2 holes being 5-mm apart, which was deemed unsuitable for interventional closure.

Interventions: After discussion with and consent from the family, the child underwent concomitant surgery for both defects. We performed an ASD repair under cardiopulmonary bypass (CPB) on the beating heart through the right oblique infra-axillary thoracotomy, and then, the standard Nuss procedure was performed using a 9-inch bar.

Outcomes: Satisfactory ASD closure was confirmed by postoperative echocardiography. Satisfactory PE correction was confirmed by physical examination and postoperative chest radiography. The postoperative recovery process was uneventful, and the patient was discharged 6 days postoperatively.

Lessons: This case shows that in carefully selected cases with concomitant PE and ASD, a combination of the Nuss procedure and ASD repair by CPB through infra-axillary thoracotomy can be safely performed, avoiding sternal incision, which leads to bleeding and sternal dehiscence, and results in better aesthetic and surgical outcomes.

Abbreviations: ASD = atrial septal defect, CHD = congenital heart defect, CPB = cardiopulmonary bypass, CT = computed tomography, PDS = polydioxanone sutures, PE = pectus excavatum.

Keywords: atrial septal defect, infra-axillary thoracotomy, Nuss procedure, pectus excavatum, simultaneous repair

1. Introduction

Pectus excavatum (PE), the most common congenital chest wall deformity, is normally an isolated congenital disorder.[1]

However, it can also occur with congenital heart defect (CHD).[2,3] Although the incidence of PE in children with CHD is only 0.17%,[4] the co-existence of these 2 defects is potentially serious; as the depressed sternum may decrease right ventricular filling and cardiac output during exercise.[5–6] When intra-cardiac shunts from the CHD are present, coexistence of these 2 defects require operative intervention. However, whether PE should be corrected simultaneously or as a separate repair is still under debate, and currently an increasing number of surgeons are advocating concurrent surgical treatment.[7] With the advancement in minimally invasive techniques, particularly for a CHD that is suitable for interventional closure, it is possible to avoid median sternotomy when repairing an intra-cardiac defect, but for a CHD that is not suitable for interventional closure, concomitant repair of the CHD and PE remains challenging for the surgeon. Herein, we describe a case of a 3.6-year-old patient who underwent the Nuss procedure and atrial septal defect (ASD) repair concomitantly under cardiopulmonary bypass (CPB) through a right oblique infra-axillary thoracotomy. To the best of our knowledge, this is the first report to demonstrate the correction of PE and CHD by this approach.

Informed written consent was obtained from the family of the patient for publication of this case report and accompanying images.
2. Case presentation
A 3.6-year-old boy was admitted to our institution with a known heart murmur and a sunken chest. The child’s growth and development were normal. Physical examination revealed concavity of the 4th–7th anterior ribs with the involvement of the corresponding sternal segments. There was a grade 2 systolic murmur at the 2nd–3rd intercostal space, abutting the left sternal border on heart auscultation. A preoperative transthoracic echocardiogram showed a 2-hole secundum ASD with an 8-mm upper hole, 5-mm lower hole, and a 5-mm distance between the 2 holes. Chest computed tomography (CT) showed asymmetrical PE with a Haller index of 4.4 (Fig. 1). After discussion with the family, the child underwent simultaneous repair for ASD and PE. The procedure was approved by the Children’s Hospital Ethics Committee of Hunan Province (HCHLL2014007). Before the operation, using chest radiography we measured the distance from the right edge of the heart to the right chest wall to be 6 cm. We entered the chest through the 4th intercostal incision, cut and then lifted the pericardium with traction line, and obtained sufficient surgical field exposure (Fig. 2). The upper and lower holes were closed by continuous suturing with 5-0 prolene, under CPB, on the beating heart.

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Figure 1. Lateral chest radiograph (A) and sagittal position chest CT scan (B) suggest severe funnel chest. CT = computed tomography.

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Figure 2. Surgical incision: (A) infra-axillary thoracotomy; (B) position of the drainage tube; (C and D) the portion of the Nuss bar inside/outside the chest.
through a minimal right oblique infra-axillary thoracotomy (approximately 5.3 cm). After ASD repair and closing the 4th intercostal incision, we changed the patient’s position from the left lateral position to the supine position. After the chest was prepared again, a transverse incision (∼2.8 cm) was made from the left through the 6th intercostal space, and a thoracoscope was placed in the right drainage port. The pleura was pierced with a curved plier at the left 6th intercostal space, and an introducer was inserted from that point. The introducer was then advanced under direct vision via the thoracoscopy from the left until it passed through the right 6th intercostal space. An introducing wire was attached to the introducer, and the introducer was pulled back out of the chest. The previously mentioned 9-inch bar (GRIKIN Advanced Material Co., Ltd., Beijing, People’s Republic of China) was guided into the chest by introducing wire from the left and then rotated 180°. The periosteum on the left 7th rib was separated and several polydioxanone sutures (PDS) were placed around the bar and the rib where they intersected. A stabilizer was attached to the left side of the bar with PDS; both sides of the stabilizer and the left side of the bar were fixed with PDS. The entire operation lasted for 110 minutes including 21 minutes of CPB. The postoperative course was uneventful, with a ventilator assist time of 4 hours and an intensive care time of 17 hours. The patient was discharged on postoperative day 6. At the current follow-up of 4 months postoperatively, workups have shown satisfactory results for repair of both defects (Fig. 3).

3. Discussion

Before the Nuss procedure, PE was repaired by the Ravitch procedure and the sterno-turnover procedure at the same time that CHD was treated by open-heart surgery. Although the surgical field of view for CHD is fully exposed, the classic Ravitch procedure has other potential disadvantages, such as major bleeding, complicated removal of costal cartilage, progressive calcification and remodeling of costal cartilage, and consequent chest wall stiffness, leading to impaired lung function. The sterno-turnover procedure can also cause sternal necrosis and osteomyelitis. After its advent, the Nuss procedure has gradually replaced the above surgical methods as the preferred procedure for PE. The traditional median sternotomy can provide sufficient exposure for repair of most heart defects and also protect the sternal blood supply and decrease the possibility of sternal ischemic complications. For patients with both defects, an increasing number of cardiac surgeons agree upon simultaneous repair through a median sternotomy for the heart repair and the Nuss procedure for PE. But this combined approach increased the risks of postoperative sternal infection and dehiscence.

Owing to the current advances in less invasive techniques, it has become more common to use these minimally invasive techniques to treat certain types of CHDs. Therefore, for patients with both defects, surgeons are attempting to use novel, minimally invasive techniques to repair both conditions.

Our team had reported the first case of successful simultaneous percutaneous closure of an ASD under the guidance of trans-esophageal echocardiography and the Nuss procedure in a 3-year-old boy with an ASD and a concurrent PE. However, when occlusion treatment is not suitable for the CHD, whether it is possible to perform cardiac repair under CPB through a minimal right oblique infra-axillary thoracotomy, which is now part of the armamentarium of cardio-thoracic surgeons to decrease the emotional burden associated with a midline sternal incision, specifically in female patients, concurrently with the Nuss procedure for PE has not been examined. It is a challenge for cardiothoracic surgeons. For patients with PE, we were concerned that displacement of the heart due to PE compression would increase the difficulty in performing a lateral thoracotomy cardiac procedure. We successfully performed this operation in a 13-kg child. Under this condition, the PE did not obstruct our operation, and no complications occurred. The reason for this is that in patients of this weight (10–15 kg), the thoracic transverse diameter is not long, and sufficient surgical exposure can be obtained after hanging the pericardium. To our knowledge, this is the first case to report the Nuss procedure and ASD repair being performed concomitantly under CPB through a minimal right oblique infra-axillary thoracotomy. This procedure preserves the integrity of the sternum and has a good cosmetic effect, without increasing the complications and prolonging hospital stay, avoiding many problems such as bleeding, sternal dehiscence, and delayed healing of the sternotomy wound. However, it may be difficult to perform this procedure in an older child with a significant cardiac shift and a long chest transverse diameter.

In conclusion, concomitant repair of CHD and PE through a minimal right oblique infra-axillary thoracotomy is well tolerated and feasible in carefully selected cases. In the future, we intend to explore more individualized approaches to the simultaneous treatment of PE and CHD.
Author contributions

Conceptualization: Yifeng Yang.
Investigation: Xicheng Deng.
Project administration: Jinhua Wang.
Resources: Jinhua Wang.
Validation: Xicheng Deng.
Writing – original draft: Guangxian Yang.

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