



The effect of thoracoscopy upon the repair of pectus excavatum



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ARTICLE INFO

Article history:

Received 1 March 2017

Received in revised form 23 June 2017

Accepted 24 July 2017

Key words:

Pectus excavatum

Thoracoscopy

Pediatric

ABSTRACT

Background/aims: The Nuss procedure is the most commonly performed operation to correct pectus excavatum (PE). Thoracoscopic assistance has been anecdotally noted to improve the safety of this operative approach. This study aimed to compare complications and clinical outcomes before and after the introduction of thoracoscopy in a single-center.

Methods: A retrospective review was performed of all patients who underwent the Nuss procedure at The Royal Children's Hospital over an 11-year period (2005–2015), collecting data on all intra-operative and post-operative outcomes.

Results: A total of 217 Nuss procedures were performed (122 non-thoracoscopic pectus repairs, 95 thoracoscopic pectus repairs). Median patient age was 14.9 years, with the majority male (185/217, 84.3%). Patient demographics (age, gender, defect severity) and postoperative recovery were comparable between the two groups. Major complications included cardiac arrest requiring internal cardiac massage, hemothorax, pneumothorax, empyema, bar displacement and infection. The overall major complication rate was low (19/217, 8.8%); however, there was a significant reduction in major complications in the thoracoscopic pectus repair group (13.1% versus 3.2%, $p = 0.02$).

Conclusions: Thoracoscopic vision during the Nuss procedure reduces the risk of major complications.

Level of evidence: Treatment study – Level III (Retrospective comparative study).

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1. Background and significance

Donald Nuss first introduced the minimally invasive repair of pectus excavatum (PE) in 1987. Since publishing his 10-year results in 1998 the Nuss procedure has become increasingly used, as it is a less invasive approach with better cosmetic outcomes than previous techniques [1]. Several modifications to the original Nuss procedure have been described, including the introduction of thoracoscopy in 1998 [2]. Anecdotally, thoracoscopy has been noted to reduce intra-operative complications, particularly significant cardiac and pulmonary injuries, by providing direct vision whilst passing the bar between the pericardium and the sternum. However, there has been no direct comparative study to prove this conclusively [4,5].

Surgical outcomes of the Nuss procedure at our center, published in 2005, described a non-thoracoscopic technique with low complication

rates [3]. Thoracoscopic-assistance began to be utilized in our center in 2009, and is now routine practice. We aimed to prove what is already assumed, that thoracoscopic assistance reduces the risk of major complications.

2. Methods

A retrospective review was performed of all patients who underwent the Nuss procedure at The Royal Children's Hospital, Melbourne during an 11-year period (January 2005–June 2015). Patients were identified from the operating theater clinical database and admissions coded by health information systems. Hospital medical records and outpatient clinic notes were reviewed from time of initial referral until completion of care post-Nuss bar removal.

Patients were divided into groups based on operative techniques used; non-thoracoscopic pectus repair (NTPR) versus thoracoscopic pectus repair (TPR). Information was collected and compared on patient demographics, defect severity (based on clinical assessment), operative details and post-operative course, including any intra- or post-operative complications, time of bar removal and cosmetic result. Major complications were defined as those that required an unplanned operation or

Abbreviations: PE, pectus excavatum; NTPR, non-thoracoscopic pectus repair; TPR, thoracoscopic pectus repair.

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invasive intervention, such as intercostal catheter insertion or readmission for intravenous (IV) antibiotics.

2.1. Statistics

Parametric data are presented as mean (SD), non-parametric as median (IQR), and categorical as proportions. A two sample *t*-test was used to compare the ages of the two groups. The Pearson chi squared test was used to establish if there was an association between the confounders (gender, surgeon), the outcomes (early and late complications), and predictors (NTPR versus TPR). Odds ratios (OR) and 95% confidence intervals (CI) were calculated for predictors and outcomes. Data were analyzed using SPSS software (IBM Corp. Released 2013. IBM SPSS Statistics, Version 21.0. Armonk, NY: IBM Corp).

3. Results

A total of 217 patients with PE were managed between 2005 and 2015. Hospital records were reviewed for all patients. Median age at time of repair was 14.9 years, and 85.3% were male. Patient demographics, comorbidities and clinical assessment of defects are summarized in Table 1. Defect severity was defined clinically by the treating surgeon. Pre-operative CT chest was not routinely performed in our center, thus precluding calculation of the Haller index. Defect severity was comparable between the two groups. Unless otherwise stated, results are expressed as non-thoroscopic pectus repair (NTPR) versus thoroscopic pectus repair (TPR).

3.1. Operative technique

The Nuss bar was inserted via two longitudinal incisions in the chest wall at the anterior axillary line. Tape was first passed behind the sternum, using long forceps, and then used to guide the bar into place. The bar, pre-curved to fit the patient’s chest, was passed behind the sternum and then flipped into place, elevating the defect. The bar was secured with stabilizers and sutured in place. All defects were aimed to be corrected with a single bar; a second bar was only inserted if the defect was not adequately corrected with a single bar.

In thoroscopic PE repairs, unilateral, right-sided thoracoscopy was performed by insertion of a 5-mm port through the right lateral chest wall just above the estimated level of the diaphragm, at the level of the anterior axillary line. The intrathoracic placement of the port was confirmed by observing lung tissue with a 5-mm scope, after which an insufflation pressure of 4–5 mmHg was used. This facilitated port entry into the right pleural cavity and passage of the Nuss bar under direct vision.

A total of 217 Nuss procedures were performed; 122 (56.2%) NTPR (2005–2010) and 95 (43.8%) with TPR (2009–2015). All operations

were performed by one of two surgeons. The median length of operation was 98 min (IQR 79–116); this was prolonged in the TPR group (116 min versus 80 min, *p* < 0.01). Fourteen patients (6.5%) had two bars inserted [11/122 (9.0%) versus 3/95 (3.2%)], the majority for a severe defect (9/14, 64.3%). Only one patient required a substernal incision for sternal lifting to assist passage of the bar; this patient was in the NTPR group. Five of the 217 (2.3%) operations were re-do operations for previously inserted bars [4/122 (3.3%) versus 1/95 (1.1%), *p* = 0.39], either for bar migration or defect recurrence.

3.2. Post-operative

Post-operative management followed a standardized protocol. A small pneumothorax was an expected finding on chest x-ray routinely performed in recovery, and was present in 79/217 (36.9%) patients [51/122 (41.8%) versus 28/95 (29.5%), *p* = 0.06]. Nineteen patients had a significant pneumothorax (>20% of chest cavity width); this occurred more frequently in the NTPR group [15/122 (12.3%) versus 4/95 (4%), *p* = 0.05]. Two affected patients required an intercostal catheter (one in each group, *p* = 0.69). The mean length of stay was 4.90 days (SD 1.71), which was not significantly different between the groups (4.8 versus 5.0 days, *p* = 0.36).

3.3. Major complications

Major complications are summarized in Table 2. There were 19 major complications (8.8%) overall. There was a significant reduction in major complications in the TPR group [16/122 (13.1%) versus 3/95 (3.16%), *p* = 0.016, OR 4.63, 95%CI 1.30–16.39].

In the NTPR group, complications included two intra-operative cardiac events. Both episodes occurred upon flipping the bar, following passage of the bar over the right ventricle wall. One patient developed bradycardia, hypotension and a drop in end tidal CO₂. The hypotension was unresponsive to 10 mcg/kg adrenaline, so internal cardiac massage via an extended thoracotomy incision was commenced. A pericardial window was performed but no significant effusion was noted. A brief period of ventricular fibrillation was cardioverted and an adrenaline infusion was commenced. Extensive post-operative investigation, including ECG Holter monitoring, failed to determine a cause; however, a cardiac MRI demonstrated a mildly dilated aortic root. The patient had some Marfanoid features.

The second patient had a sudden drop in end tidal CO₂ and blood pressure during bar rotation, requiring repeated metaraminol boluses. An intra-operative transesophageal echocardiogram demonstrated good ventricular function and a small apical pericardial effusion without tamponade. A chest x-ray demonstrated bilateral large pleural effusions. The patient required postoperative inotropes overnight.

Table 1
Patient demographics and pre-operative assessment.

		Non Thoroscopic (NTPR)	Thoroscopic (TPR)	Total	p Value
Age	Mean (SD)	14.59 (2.27)	15.39 (1.12)	14.9 (1.92)	0.002
Gender	Male n (%)	100 (82.4%)	83 (87.4%)	183 (84.3%)	0.28
Comorbidities	Marfan's Syndrome	0 (0.0%)	2 (2.1%)	2 (0.9%)	0.19
	Marfanoid features	11 (9.0%)	2 (2.1%)	13 (6.0%)	0.03
Scoliosis		8 (6.6%)	11 (11.6%)	19 (8.8%)	0.15
	Asthma	18 (14.8%)	18 (18.9%)	36 (16.6%)	0.26
	Other	10 (8.2%)	8 (8.4%)	18 (8.3%)	0.57
	Mild	5 (4.1%)	16 (16.8%)	21 (9.7%)	0.08 ⁱ
Pectus Severity ⁱ	Moderate	68 (55.7%)	54 (56.8%)	122 (56.2%)	
	Severe	39 (32.0%)	23 (24.2%)	62 (28.6%)	
	Not recorded	10 (8.2%)	2 (2.1%)	12 (5.5%)	
Chest wall symmetry	Symmetrical	78 (63.9%)	63 (66.5%)	141 (65%)	0.32
	Asymmetrical	33 (27.0%)	32 (33.7%)	65 (30.0%)	
	Not recorded	11 (8.9%)	0	11 (5.0%)	

ⁱ Pectus severity and symmetry were assessed clinically by the primary surgeon. Pectus severity compared mild and moderate versus severe.

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