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Minimally invasive repair of pectus excavatum: Analysis of the NSQIP database and the use of thoracoscopy☆,☆☆

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ABSTRACT

Background: The minimally invasive repair of pectus excavatum (MIRPE) has been widely accepted and has become a viable alternative to the open Ravitch technique. MIRPE has evolved over time with some advocating that a safe repair can be accomplished without direct visualization utilizing thoracoscopy. The MIRPE with and without a thoracoscopic approach has not been previously analyzed from a nationwide database to determine differences in safety and short-term outcomes.

Methods: The American College of Surgeons National Surgical Quality Improvement Program-Pediatric (NSQIP-P) 2012–2015 database was used in identifying patients that had MIRPE using Current Procedural Terminology (CPT) codes and ICD-9CM/ICD-10CM postoperative diagnosis codes. Outcomes of interest were readmissions, reoperations, complications, cardiothoracic injury, operative time, and duration of hospital stay after surgery for MIRPE with and without thoracoscopy. Descriptive statistics, simple and multivariable logistic regressions, Fisher's exact, and Wilcoxon rank sum test were used to determine any differences in 30-day postoperative outcomes.

Results: There were 1569 MIRPE cases included. 15.9% (N = 249) of MIRPE were done without thoracoscopy. There were no significant differences with the use of thoracoscopy compared to without thoracoscopy in the rate of readmissions (2.5 vs 4.8%; $p = 0.06$), reoperations (1.4 vs 2.0%; $p = 0.57$), postoperative complications (2.6% vs 3.2%; $p = 0.52$), and cardiothoracic injuries (0.2% vs 0.0%; $p = 1.00$). Unadjusted odds ratios (ORs) for readmission and reoperation comparing MIRPE with thoracoscopy to MIRPE without thoracoscopy were 0.51 ($p < 0.05$) and 0.71 ($p = 0.50$), respectively. Adjusted ORs were 0.49 ($p = 0.04$) and 0.71 ($p = 0.50$), respectively. There were no reported deaths, but two cardiothoracic injuries were recorded in the group with thoracoscopy. MIRPE with thoracoscopy was associated with longer operative time (mean 13.0 min; $p = 0.00$) and longer hospital stay (mean 0.37 days; $p < 0.01$) compared to MIRPE without thoracoscopy. No data were available for the severity of the pectus defect.

Conclusion: MIRPE has a low adverse event rate with no difference in reoperations, postoperative complications, and cardiothoracic injuries with or without the use of thoracoscopy. There may be a higher rate of readmissions in the nonthoracoscopic group. While the technique used remains the surgeon's decision, the use of thoracoscopy may be unnecessary and is at an added cost.

Type of study: Treatment study (retrospective comparative study).

Level of evidence: Level III.

Pectus excavatum is a congenital deformity of the chest wall which results from abnormal growth of the ribs and sternum. It occurs in an estimated 1 out of 400 births having a male to female ratio of 9:1. It is the most common anterior chest wall deformity (90% of all chest wall deformities) and surgery has been the only means of correction [1]. Many patients present for chest wall repair owing to limitations in exercise tolerance. Before 1987, the Ravitch technique was the standard surgical approach to the repair of pectus excavatum [2]. In 1987, Dr. Donald Nuss performed the first minimally invasive repair of pectus excavatum (MIRPE) and later introduced the technique to the American Pediatric Surgical Association in May 1997 [3]. The technique was less radical and provided excellent results which promoted its widespread use [1]. Complications such as bar displacement, infectious complications, pleural effusion, pneumothorax and cardiac perforation have been reported since its introduction [4,5]. The technique has

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undergone modifications over time to improve its safety and reduce associated complications [3]. Previous studies have compared the outcomes for the Ravitch and Nuss techniques in which similar complication rates were found (except in adults where complications were higher with Nuss) but the Nuss procedure had lower blood loss and shorter operative time [6].

The original MIRPE that was introduced by Dr. Donald Nuss was done without the aid of thoracoscopy. Over time, this technique has been modified to be performed with a thoracoscope as part of measures to improve its safety. A recent study analyzed the addition of thoracoscopy to determine if it led to a lower rate of complications. The authors concluded that this modification potentially reduces the risk of cardiac complications without increasing the rate of minor complications [7]. Using the National Surgical Quality Improvement Program-Pediatric (NSQIP-P) database, we examine the addition of thoracoscopy on improving the safety of MIRPE, comparing short-term complications and outcomes of the modified Nuss technique. We hypothesize that MIRPE with thoracoscopy is associated with fewer complications and superior short-term outcomes than without thoracoscopy.

1. Methods

This study was approved by the Johns Hopkins Institutional Review Board (IRB00088002). The American College of Surgeon's National Surgical Quality Improvement Program-Pediatric (ACS-NSQIP-P) participant use data files (PUF) from 2012 to 2015 were reviewed for cases of pectus excavatum undergoing MIRPE with or without thoracoscopy. Patients were selected using both current procedural terminology (CPT) codes 21742 (MIRPE without thoracoscopy) and 21743 (MIRPE with thoracoscopy) and postoperative diagnosis ICD-9CM code 754.81 and ICD-10CM code Q67.6 for pectus excavatum. Patients with coding specific for pectus carinatum and other chest wall deformities were excluded. Cases that were labeled as urgent and emergent were also excluded to include only elective cases.

Baseline demographic characteristics, comorbidities, type of surgery and postoperative outcomes within 30 days after surgery were collected. Demographic characteristics collected include age, sex, and race. Comorbidities were grouped into cardiac, pulmonary, neurologic and others. Cardiac comorbidities included previous cardiac surgery, and minor, major or severe cardiovascular risk factors. Pulmonary comorbidities were asthma, chronic lung disease/bronchopulmonary dysplasia and structural pulmonary abnormality. Neurologic comorbidities were developmental delay/impaired cognitive status, seizure disorder, cerebral palsy, neuromuscular disease, structural central nervous system abnormality, and tumor involving the central nervous system. The other comorbidities were esophageal/gastric/intestinal disease, bleeding disorder, hematologic disorder, congenital malformation, and past history of childhood malignancy.

The primary comparison variable was MIRPE with compared to without thoracoscopy. The main outcomes of interest were 30-day related reoperations and related readmissions, operative time, duration of hospital stay after surgery, cardiothoracic injury, and postoperative complications. Cardiothoracic injury was defined as a concurrent or other procedure indicative of a cardiothoracic injury. Postoperative complications were defined as the occurrence of any of the following: superficial incisional surgical site infection, deep incisional surgical site infection, organ/space surgical site infection, wound disruption, pneumonia, urinary tract infection, nerve injury, bleeding/transfusion, sepsis, superficial wound disruption, and venous thromboembolism. Readmission or reoperation outcomes were related to MIRPE as determined by NSQIP-P criteria.

Descriptive statistics were used for demographic variables, comorbidities, and outcomes by MIRPE with and without thoracoscopy. Fisher's exact test was used to compare readmissions, reoperations, cardiothoracic injury and postoperative complications among the two groups. Simple and multivariable logistic regressions were used for reoperations and readmissions comparing MIRPE with thoracoscopy to those without. Wilcoxon rank sum test was run for the operative time and hospital stay. Analyses were performed using STATA MP 14.2 (College Station, Texas).

2. Results

A total of 1569 MIRPE cases were included in this study, with 249 (15.9%) being done without thoracoscopy and 1320 (84.1%) with thoracoscopy. 2.8% of patients in the nonthoracoscopy group and 4.5% of patients in the thoracoscopy group were less than 12 years old with median ages of 15.2 and 15.3 years, respectively. The majority of the patients were males (87.2% in nonthoracoscopy group and 82.5% in thoracoscopy group) and white (92.0% in nonthoracoscopy group and 90.8% in thoracoscopy group). Asthma was the most common individual comorbidity among study subjects with 5.6% in the nonthoracoscopy group and 8.8% in the thoracoscopy group [Table 1].

The overall readmission rate was 2.9% with no difference found between those with or without the use of thoracoscopy (2.5% versus 4.8%; $p = 0.06$). The total reoperation rate was 1.5%, also with no statistical difference found between groups (1.4% versus 2.0%; $p = 0.57$). There were no differences in postoperative complications comparing those with thoracoscopy to those without (2.6% versus 3.2%; $p = 0.52$) with an overall rate of 2.7%. There were no deaths reported in the study. Two procedures (repair cardiac wound without bypass and repair laceration diaphragm any approach) were performed alongside the MIRPE, potentially indicative of inadvertent cardiothoracic injuries. These both occurred in the thoracoscopy group, with no inadvertent injuries identified in the group without thoracoscopy (0.2% versus 0.0%; $p = 1.00$) with an overall rate of 0.1% [Table 2].

The average operation time for MIRPE with thoracoscopy was 87.37 ± 35.38 min and 74.41 ± 51.14 min for those done without thoracoscopy with a difference of 12.96 min ($p = 0.00$). Hospital stay after surgery was 4.41 ± 1.91 days for MIRPE with thoracoscopy and 4.04 ± 1.31 days without thoracoscopy with a difference of 0.37 days ($p < 0.01$) [Table 2].

Table 1
Demographics and clinical characteristics of patients undergoing mIRPE.

Patient characteristics	MIRPE without thoracoscopy N = 249	MIRPE with thoracoscopy N = 1320	P-value
Age in years, median (IQR)	15.2 (14.0–16.3)	15.3 (14.1–16.3)	0.68
Age category, n (%)			
< 12 years	7 (2.8)	60 (4.5)	0.39
12–15 years	165 (66.3)	831 (63.0)	
> 15 years	77 (30.9)	429 (32.5)	
Sex, n (%)			
Male	217 (87.2)	1089 (82.5)	0.08
Female	32 (12.9)	231 (17.5)	
Race, n (%)			
White	229 (92.0)	1198 (90.8)	
Black or African American	3 (1.2)	13 (1.0)	
Asian	3 (1.2)	24 (1.8)	0.92
American Indian or Alaska Native	1 (0.4)	4 (0.3)	
Native Hawaiian or Other Pacific Islander	1 (0.4)	5 (0.4)	
Unknown/Not reported	12 (4.8)	76 (5.8)	
Preoperative Comorbidities, n (%)			
Cardiac	18 (7.2)	136 (10.3)	0.16
Pulmonary	24 (9.6)	185 (14.0)	0.07
Neurologic	2 (0.8)	62 (4.7)	<0.01
Others	62 (24.9)	312 (23.6)	0.69

IQR = interquartile range.
Others: esophageal/gastric/intestinal disease, hematologic disorder, bleeding disorder, congenital malformation, past history of childhood malignancy.