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Outcomes for thoracoscopic versus open repair of small to moderate congenital diaphragmatic hernias

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ABSTRACT

Introduction: Indications for thoracoscopic versus open approaches to repair congenital diaphragmatic hernia (CDH) are unclear as the variability in defect size, disease severity and patient characteristics pose a challenge. Few studies use a patient and disease-matched comparison of techniques. We aimed to compare the clinical outcomes of open versus thoracoscopic repairs of small to moderate sized hernia defects in a low risk population.
Methods: All neonates receiving CDH repair of small (type A) and moderate (type B) size defects at an academic children's hospital between 2006 and 2016 were retrospectively reviewed and analyzed. Patients <36 weeks gestation, birth weight <1500 g, or requiring extracorporeal life support were excluded. Demographics, including CDH severity index, and hernia characteristics were recorded. The primary outcome parameter was recurrence. Secondary outcomes included length of hospital stay, length of mechanical ventilation, time to goal feeds, and mortality.
Results: The 51 patients receiving thoracoscopic (35) and open (16) repairs were similar in patient and hernia characteristics, with median 2-year follow-up for both groups. Patients with thoracoscopic repair had shorter hospital stay (16 vs. 23 days, $p = 0.03$), days on ventilator (5 vs. 12, $p = 0.02$), days to start of enteral feeds (5 vs. 10, $p < 0.001$), and days to goal feeds (11 vs. 20, $p = 0.006$). Higher recurrence rates in the thoracoscopic groups (17.1% vs. 6.3%) were not statistically significant ($p = 0.28$). Median time to recurrence was 88 days for the open repair and 183 days (IQR 165–218) for the thoracoscopic group. There were no mortalities in either group.
Conclusions: In low risk patients born with small to moderate size defects, a thoracoscopic approach was associated with decreased hospital length of stay, mechanical ventilation days, and time to feeding; however, there was a trend towards higher recurrence rates.
Level of evidence: Level III.

1. Background

Initially described in 1995, thoracoscopic approaches to repair of congenital diaphragmatic hernias have been widely adopted by many pediatric surgeons. [1] In fact, a recent survey of 161 pediatric surgeons showed that 89% perform thoracoscopic repairs, while also demonstrating a significant lack of consensus on operative indications. [2] The survey highlights stark inconsistencies among pediatric surgeons on choosing optimal candidates for a thoracoscopic repair.

Recent advances in surgical technology, critical care, and technical abilities have undoubtedly extended opportunities for minimally invasive approaches [3,4]. Thoracoscopic repair of congenital diaphragmatic hernias (CDH) have led to a significant reduction in hospital stay, shorter time to goal feeds, and lower mortality in select patients. [5] Unfortunately, a majority of studies comparing the two approaches do not account for the multiple comorbidities related to mortality and recurrence. These risks not only relate to patient selection, but also hernia characteristics, such as preoperative imaging and hernia size. [6] A recent study by Costerus et al. demonstrated higher recurrences in the thoracoscopic group in a cohort of neonates with low cardiopulmonary risk. [7] While they were successful in case matching patient characteristics, however the type and size of the hernia was not analyzed for comparison.

This study aimed to evaluate the operative outcomes in a low risk neonatal population with small to moderate sized defects. One of the focuses of this study was to create a clinical situation where operative and patient hemodynamic risk is low. This study is the first of its kind to evaluate a homogenous low risk patient population and their outcomes related to thoracoscopic and open repairs of small to moderate hernias.

2. Methods

This study was approved by the University of Michigan Institutional Review Board. A retrospective review of charts was performed for all

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patients treated for CDH as neonates between 2006 and 2016. The patients with small to moderate-sized defects were selected for analysis using the previously reported categories by the Congenital Diaphragmatic Hernia Study Group. A small defect, or "A" defect, is defined as being entirely surrounded by muscle. A "B" defect, or moderate size hernia, had <50% portion of the chest wall devoid of diaphragm tissue. [8] The size was determined based on review of the operative note description and designation in the operative report of size. In an attempt to remove high risk patients, any patient receiving extracorporeal life support, with gestational age less than 36 weeks, or birth weight below 1500 g were excluded from the study group.

Demographics were obtained including gestational age (weeks), gender, birth weight (kg), time to surgery (days), weight at surgery (kg), and 5 min APGAR scores. Post-natal CDH mortality risk was also calculated individually for each patient. Utilizing the risk groups reported by post-natal prediction model by Brindle et al., variables were used to calculate the numerical number and categorized into low, intermediate, and high-risk patients [9,10]. Additional details such as major cardiac anomalies, preoperative ventilation settings, pulmonary hypertension, and the use of vasopressors were individually collected as well (Table 1).

Additional hernia and operative characteristics were also gathered (Table 1). These include preoperative imaging with stomach or liver visualized in the chest (defined as "up"), defect side (left/right), and the size of the hernia by type ("A", "B"). Operative characteristics such as hernia sac, utilization of a patch, and type of patch utilized were documented. The operative approach, thoracoscopic or open repair, was decided at the discretion of the operating surgeon. All operating surgeons perform both open and thoracoscopic repairs. Intraoperative chest tube placement was at the discretion of the surgeon. Regarding postoperative care, a standardized approach to enteral feeding and extubation criteria was followed. Feedings were initiated when patients exhibited either return of bowel function or nasogastric output was less than 3 ml/kg over eight hours. Furthermore, goal-feeding protocols were used based on patient's weights. Extubation readiness was assessed when patients met standardized criteria ($FiO_2 \leq 40$, PEEP = 5, and tolerance to sprinting trials for one hour). With regard to follow-up, we routinely perform postoperative visits and routine chest x-rays at 1–2 months postoperatively, 6 weeks, and yearly unless symptoms present. Additionally, recommendations were followed as previously suggested by the American Academy of Pediatrics, where a multidisciplinary approach is utilized for follow-up. [11] This includes evaluations from occupational therapy, physical therapy, social work, pediatric cardiology, pediatric pulmonology, and finally, progression of neurological and psychological developmental.

Primary outcome for this study was recurrence. Recurrences were defined by confirmation on imaging or reoperation. Secondary outcomes consisted of time to recurrence (days) hospital length of stay (days), time to initial enteral feeds (days), time to goal enteral feeds (days), operative time (min), and mortality (see Table 2). Additional data on outcomes related to each individual recurrence can be seen in Table 3.

Open versus thoracoscopic repairs were compared using Chi-square or Fisher's exact tests for categorical variables and independent t-test and Mann–Whitney tests for continuous variables. A bivariate association was performed using Chi-squared test for clinically relevant variables relating to recurrence. These included patch utilization, operative approach, liver up, side of defect, stomach up, pulmonary hypertension, and size of defect. All analyses were performed using STATA13. A p-value <0.05 was considered statistically significant.

3. Results

A total of 51 patients treated at C.S. Mott Children's Hospital met criteria for analysis. A thoracoscopic repair was attempted in 37 patients, with 35 successfully completed. A total of 16 including the converted patients, received open repairs. The main reasons for conversion were inability to successfully reduce hernia components thoracoscopically, and a large defect requiring patch repair early in the experience. Baseline demographics including gender, birthweight (kg) age, weight at surgery (kg), 5 min APGAR, CDH mortality index, pulmonary hypertension, major cardiac anomalies, and vasopressor requirement were similar between groups (Table 1). CDH mortality index was statistically similar between each group (p = 0.98) with a majority of patients (62%) classified as being low risk. Preoperative imaging demonstrated liver up in left sided defects in 2 (6%) thoracoscopic patients

Table 1
Patient and operative characteristics.

	Open (n = 16)		Thoracoscopic (n = 35)		*p* Value
Patient demographics					
Gender	Male = 11 (69%)		Male = 16 (46%)		*0.11*
Birthweight (median, IQR)	3.3 kg (3.0–3.5)		3.4 kg (2.8–3.7)		*0.24*
Age (median, IQR)	38 weeks (37–39)		39 weeks (38–40)		*0.1*
Weight at surgery (median, IQR)	3.4 kg (3.1–3.6)		3.4 kg (2.9–3.8)		*0.85*
APGAR 5 min (median, IQR)	8 (7–9)		8 (8–9)		*0.31*
CDH Mortality Index	Low Intermediate High	10 5 1	Low Intermediate High	22 11 2	*0.98*
Pulmonary hypertension	3 (20%)		7 (20.6%)		*0.6*
Major cardiac defects	1 (6.7%)		0		
Vasopressor requirement	5 (31.2%)		10 (28%)		*0.55*
Follow-up (mean, range)	46 months (1–95)		31 months (1–102)		*0.3*
Median (IQR)	48 months (13–74)		19 months (10–55)		
Operative Characteristics					
	Open (n = 16)		**Thoracoscopic (n = 35)**		*p Value*
Hernia side	Right Left	5 (33.3%) 11 (68.8%)	Right Left	4 (11.4%) 31 (88.6%	*0.095*
Liver "up" in left sided CDH	1 (6%)		2 (6%)		
Stomach "up"	5 (31%)		8 (23%)		*0.38*
Hernia type	A (small) B (moderate)	15 (88%) 3 (13%)	A (small) B (moderate)	30 (86%) 5 (14%)	*0.62*
Hernia sac present	5 (31%)		8 (23%)		*0.38*
Patch repair	3 (19%)		9 (25%)		*0.44*
Intraoperative chest tube	4 (25%)		16 (46%)		*0.14*
Operative time (median, IQR)	160 min (120–173)		167 min (132–209)		*0.31*