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Introduction of pediatric thoracoscopic lung resections in a low-volume center – feasibility, outcome and cost analysis

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ABSTRACT

Background: Early series of pediatric thoracoscopic surgery have reported high conversion rates and significant complications. This study investigated the introduction of pediatric thoracoscopic lung resections in a low-volume center with reference to corresponding open thoracotomy procedures with regards to operative times, length of stay, cost of admission, and outcomes.

Methods: A single surgeon series. Data from the first 10 consecutive thoracoscopic lung resections were compared to a cohort of 10 consecutive open lung resections performed before the introduction of the thoracoscopic technique. All operations were performed between December 2015 and October 2021. The median follow-up was 34 months (range 4–65).

Results: The cohort included 14 lobectomies (8 thoracoscopic and 6 open) for congenital pulmonary airway malformation (CPAM), and 6 resections (mainly non-anatomic) of pulmonary sequestration (2 thoracoscopic and 4 open). One lobectomy required conversion to thoracotomy, and one patient required reinsertion of a chest drain after open lobectomy due to persistent air leak. No other complications were recorded. All patients were asymptomatic at their follow-up. There was no significant difference in the mean age, mean weight, operative times, and intraoperative blood loss between open and minimally invasive procedures. Thoracoscopic technique was associated with significantly shorter stay at pediatric intensive care unit and shorter overall inpatients stay.

Conclusion: Thoracoscopic lung resections can be safely introduced in a low-volume center with comparable cost, operative time, and results and significantly shorter inpatient stay.

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KEYWORDS
Lung resection; minimally invasive surgical procedures; pediatrics; thoracoscopy

Introduction

The main benefit and aim of minimally invasive surgery (MIS) are to minimize tissue damage. Recent development of small, high-quality instruments has allowed these operations to be performed even in neonates [1,2]. This has led to exponentially increasing popularity of thoracoscopic surgery [3]. Current evidence suggests that thoracoscopic surgery in pediatric population is associated with improved recovery but also longer operative times compared to conventional open thoracic surgery [4]. However, there are no studies on cost-effectiveness of thoracoscopic surgery in pediatric population.

Thoracoscopy is considered technically more difficult than open surgery [5], and therefore it is regarded as the last step in MIS training by many pediatric surgeons [6]. Also, a sufficient case volume is required to reach a plateau of competence, which is typically challenging in pediatric surgery [5]. According to the European Society of Pediatric Endoscopic Surgeons (ESPES), at least 30 procedures as assistant and more than 50 basic procedures as primary surgeon should be included in a valid MIS training curriculum [7].

On average, our pediatric surgery unit has less than five lung resections annually, which makes completion of validated MIS training challenging. However, collaboration with adult thoracic surgeons at our hospital facilitated the introduction of minimally invasive lung resections regardless of a low case volume.

This study aims to analyze the introduction of pediatric thoracoscopic lung resections in a low-

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volume center to assess the feasibility, safety, and cost-effectiveness of a new technique in a teaching hospital without prior experience in pediatric thoracoscopic surgery.

Materials and methods

We performed a retrospective study on lung resections performed by a single pediatric surgeon. Data from first 10 thoracoscopic lung resections were compared to a cohort of 10 consecutive open lung resections performed before the introduction of thoracoscopic technique. Patients were identified in the operating theatre management software (Centricity Opera 4.5, GE Healthcare, Barrington, IL) by searching with relevant operation codes for lung resections: GDC00 and GDC01 for open and thoracoscopic lobectomy, and GDB96 and GDB97 for open and thoracoscopic resection of lung. Performed operations are all registered according to the Finnish version of NOMESCO (Nordic Medico-Statistical Committee) Classification of Surgical Procedures (NCSP).

Surgical technique

All operations were performed under general anesthesia at our unit of pediatric surgery. After endotracheal intubation, patients were placed in lateral decubitus position. For open procedures, a standard posterolateral muscle-splitting thoracotomy was utilized. The main vessels were divided with absorbable sutures and non-absorbable suture was used for bronchial division. For thoracoscopic procedures, single lung ventilation was required and contralateral mainstem intubation was confirmed with bronchoscopy by the anesthetist. Three 5-mm trocars were inserted, and CO_2 insufflation was utilized to create pneumothorax and complete lung collapse. A 5-mm surgical stapler (JustRight Surgical, Louisville, CO) was the primary device for vessel and bronchial sealing as described by Dr Rothenberg [8]. Anterior incision was extended up to 3 cm before specimen retrieval; a retrieval bag is not required. A chest drain was left in place routinely for both open and thoracoscopic procedures. As the new minimally invasive technique was introduced, an adult thoracic surgeon experienced with minimally invasive lung resections was working as the first assistant holding the camera to shorten the learning curve, as recommended in literature [3].

Outcome measures and data collection

Primary outcome measures were length of stay (LOS) at pediatric intensive care unit (PICU) and total inpatient stay, time to chest drain removal, complications, readmissions, requirement for postoperative pain medication (adjusted for patients' weight), operation times, intraoperative blood loss, and costs related to surgery and total admission. Also, data on patients' age, weight, diagnosis, and performed operation(s) were collected. Routine follow-up included chest radiograph at 3 and 12 months postoperatively. Complications were graded according to the Clavien–Dindo classification system [9].

Statistical analysis

One-way ANOVA and Wilcoxon rank test were used to compare continuous variables and chi-square for categorical variables. A significance level of $p < 0.05$ (two-tailed) was set. Analyses were performed using JMP Pro, version 15.1.0 for Windows (SAS Institute Inc., Cary, NC).

Results

The thoracoscopic cohort included 8 lobectomies for congenital pulmonary airway malformation (CPAM) and two resections of pulmonary sequestration. The open cohort consisted of 6 lobectomies for CPAM and 4 resections of pulmonary sequestration. All operations were performed between December 2015 and October 2021. The median follow-up length was 12 months (range 3–34) and 54 months (36–69) for thoracoscopic and thoracotomy cohort, respectively. There were no significant differences in the median age, median weight, operative times, and intraoperative blood loss between open and minimally invasive procedures. The thoracoscopic technique was associated with a significantly shorter stay at pediatric intensive care unit (PICU) and shorter overall inpatients stay, as well as shorter time to chest drain removal postoperatively (Table 1).

One lobectomy required conversion to thoracotomy due to bleeding, which could not be managed thoracoscopically. Only one complication was recorded (Clavien-Dindo IIIb). This patient was analyzed as part of thoracoscopic cohort. A patient was readmitted for reinsertion of a chest drain under general anesthesia one week after open lobectomy due to persistent air leak. All patients attended and were asymptomatic at their routine follow-up visits at 3 and 12 months postoperatively

Table 1. Comparison of open and thoracoscopic operations showing significant differences in length of PICU and inpatient stay duration only.

	Thoracoscopic operation ($n = 10$)	Open operation ($n = 10$)	p Value
Age (years)	0.9 (0.7–9.7)	1.0 (0.7–2.0)	0.46
Weight (kg)	9.6 (8.0–40)	9.6 (6.7–12.4)	0.46
Operative time (minutes)	107 (60–148)	95 (61–203)	0.87
Blood loss (ml)	10 (2–100)	18 (2–120)	0.22
PICU stay (days)	1 (1–2)	2 (1–3)	0.015
Inpatient stay (days)	2 (1–6)	4 (3–5)	0.005
Chest drain removal (days)	1 (1–2)	2 (1–3)	0.039
Cost of operation (€)	5447 (3212–9010)	4373 (2108–6176)	0.10
Total cost of admission (€)	8611 (7039–16,271)	9568 (7046–12,833)	0.49

Values are given as median and range.

Table 2. Comparison of postoperative main management and dosage of pain medications.

	Thoracoscopic operation ($n = 10$)	Open operation ($n = 10$)	p Value
Epidural anesthesia	2/10 patients	8/10 patients	0.02
Oxycodone (mg/kg)	0.57 (0.45–1.39)	1.17 (0.51–2.09)	0.01
Dexmedetomidine (ug/kg)	16.8 (0–46.6)	37.7 (0–93.8)	0.01
Paracetamol (mg/kg/day)	71.0 (51.7–106.9)	61.1 (47.4–67.3)	0.03
Naproxen (mg/kg/day)	7.3 (0–13.4)	5.6 (0–13.3)	0.40

Values are given as median and range.

and chest radiographs revealed no signs of complications.

For cost analysis, the hospital charges for the surgical procedure as well as the total cost of the admission were analyzed and compared between open and minimally invasive cohorts with all charges converted to 2021 hospital rates. For 2021, the list prices of thoracoscopic lobectomy including operating theatre and anesthesia were 3940 euros (€) and of open lobectomy 4260 €, respectively. The list prices are predefined for specific operation codes. For our patients, the operative costs of thoracoscopic operations were higher than in conventional open surgery; 5448 € versus 4373 €, including the price of special instrumentation required for minimally invasive surgery. The total charges of the admission were nevertheless lower in the thoracoscopic cohort; 8611 € versus 9568 € with shorter total and PICU length of stay. However, no statistically significant difference was observed (Table 1). Total charges, which in our country are all covered by patient's municipality, include both the price of surgery and postoperative care.

There was a significantly higher frequency of postoperative epidural anesthesia after open thoracotomy (8/10 versus 2/10 patients, $p = 0.02$). The total amount of sedative medication Dexmedetomidine; Dexdor®) as well as the total requirement for opioids (Oxycodone) was significantly lower after minimally invasive surgery. Daily dose of paracetamol was higher in thoracoscopic group while no difference was observed in utilization of Naproxen (Table 2). All patients were discharged with Paracetamol and Naproxen or Ibuprofen only, and no opioids were prescribed.

Discussion

We show here that thoracoscopic lung resections can be safely introduced in a low-volume center with comparable short- and mid-term results, operative time, and hospital charges. The thoracoscopic approach eases the burden on the patients and their families with significantly shorter inpatient stay and lower need for postoperative epidural anesthesia, sedation, and opioids.

Thoracoscopic lobectomy in infants and children is considered a technically challenging procedure [8]. Hence, at least 50 cases should be included in a valid MIS training curriculum [7]. Fifty cases are also considered as a cut-off point for learning curve in operative time and stable outcomes [10]. A meta-analysis on thoracoscopic resection of asymptomatic congenital lung malformation reported a mean operative time of 142 min in 404 minimally invasive procedures [11]. The operative times reported here were comparable with our own control group as well as the median operative time (100 min) reported by Park et al. after more than 50 performed lung resections [10]. Hence, our results would suggest that the learning curve can be shortened by the assistance provided by adult thoracic surgeon.

One of the main disadvantages of thoracoscopic lung resections in pediatric patients is longer operative time compared to open surgery, which has been reported in several studies [12–14], including one meta-analysis [11]. However, this finding has not been confirmed in all published reports [15]. In our study, the operative times were comparable between open and minimally invasive cohorts despite recent introduction of

thoracoscopic technique. This may be explained in part by having two complicated lobectomies with previous infection in open cohort compared to one lobectomy for CPAM and lung abscess in minimally invasive cohort. On the other hand, the operative times for thoracoscopic lung resections reported here were comparable with those of larger series [10], as stated above.

There is robust evidence that the length of hospital stay is significantly shorter for thoracoscopic lung resections confirmed by two meta-analyses (evidence level 3a) [11,15]. Shorter time in intensive care unit has also been reported as an advantage of thoracoscopic surgery [16,17]. In accordance with previous reports, we also observed significantly shorter hospital and PICU stay after minimally invasive surgery. Thoracoscopy was associated with faster time to chest drain removal, which is supported by several previous studies [16–18] including one meta-analysis [15].

Early studies have reported that thoracoscopic surgery is associated with less regional anesthesia [19] and narcotics use [20]. These findings were supported by our results as requirement for epidural anesthesia, sedatives, and opioids was lower in thoracoscopic cohort. Thus, it seems evident that minimally invasive surgery is associated with significantly reduced postoperative pain compared to conventional surgery.

According to a recent systematic review, the majority of adult studies have reported lower or similar overall costs for thoracoscopic lobectomies compared with open surgery [21]. However, similar studies in pediatric population are sparse. While thoracoscopy is a safe alternative to open surgery, the need for cost-analysis has been noted [22]. A US study reported that thoracoscopic resection of lung malformations was associated with somewhat higher overall cost than open surgery, yet no statistically significant difference was observed [23]. However, our data would suggest that thoracoscopic technique is associated with similar overall cost compared to conventional approach.

There is some controversy regarding the treatment of asymptomatic CPAM/congenital lung malformations [24,25]. Thoracoscopic resection provides a means of surgery with lower morbidity than traditional open surgery and can safely be introduced to a low-volume center without significant financial investment. We believe MIS should be introduced to low-volume centers to ease the burden of surgery for affected patients within pediatric surgery in general [26].

Strengths and limitations

The strength of the current study is the inclusion of ten consecutive patients in both cohorts and no patients were lost to follow-up. The main limitation is the small sample size and heterogeneity of performed operations.

Conclusions

The findings of the current study suggest that introduction of pediatric thoracoscopic lung resections in a small volume center is safe, feasible, and economically justifiable. In our experience, the assistance provided by the adult thoracic surgeon has been crucial in the introduction of this new technique.

Geolocation information

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Disclosure statement

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References

[1] Kuebler JF, Ure BM. Minimally invasive surgery in the neonate. Semin Fetal Neonatal Med. 2011;16(3):151–156.

[2] Macchini F, Zanini A, Morandi A, et al. Thoracoscopic surgery for congenital lung malformation using miniaturized 3-mm vessel sealing and 5-mm stapling devices: single-center experience. J Laparoendosc Adv Surg Tech A. 2020;30(4):444–447.

[3] Ure B. Enthusiasm, evidence and ethics: the triple E of minimally invasive pediatric surgery. J Pediatr Surg. 2013;48(1):27–33.

[4] Kiblawi R, Zoeller C, Zanini A, et al. Video-Assisted thoracoscopic or conventional thoracic surgery in infants and children: current evidence. Eur J Pediatr Surg. 2021;31(1):54–64.

[5] Macchini F, Leva E, Gentilino V, et al. Mentoring in pediatric thoracoscopy: from theory to practice. Front Pediatr. 2021;9:630518.

[6] Lau C-T, Wong KKY. Pediatric minimal invasive surgery—thoracoscopic lobectomy. Ann Laparosc Endosc Surg. 2018;3(12):94–94.
[7] Esposito C, Escolino M, Saxena A, et al. European society of pediatric endoscopic surgeons (ESPES) guidelines for training program in pediatric minimally invasive surgery. Pediatr Surg Int. 2015;31(4): 367–373.
[8] Rothenberg S. Thoracoscopic lobectomy in infants and children utilizing a 5 mm stapling device. J Laparoendosc Adv Surg Tech A. 2016;26(12): 1036–1038.
[9] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240(2):205–213.
[10] Park S, Kim ER, Hwang Y, et al. Serial improvement of quality metrics in pediatric thoracoscopic lobectomy for congenital lung malformation: an analysis of learning curve. Surg Endosc. 2017;31(10): 3932–3938.
[11] Adams S, Jobson M, Sangnawakij P, et al. Does thoracoscopy have advantages over open surgery for asymptomatic congenital lung malformations? An analysis of 1626 resections. J Pediatr Surg. 2017; 52(2):247–251.
[12] Laje P, Pearson EG, Simpao AF, et al. The first 100 infant thoracoscopic lobectomies: observations through the learning curve and comparison to open lobectomy. J Pediatr Surg. 2015;50(11):1811–1816.
[13] Rahman N, Lakhoo K. Comparison between open and thoracoscopic resection of congenital lung lesions. J Pediatr Surg. 2009;44(2):333–336.
[14] Kunisaki SM, Powelson IA, Haydar B, et al. Thoracoscopic vs open lobectomy in infants and young children with congenital lung malformations. J Am Coll Surg. 2014;218(2):261–270.
[15] Nasr A, Bass J. Thoracoscopic vs open resection of congenital lung lesions: a meta-analysis. J Pediatr Surg. 2012 May;47(5):857–861.
[16] Lau CT, Leung L, Chan IH, et al. Thoracoscopic resection of congenital cystic lung lesions is associated with better post-operative outcomes. Pediatr Surg Int. 2013;29(4):341–345.
[17] Lau CT, Wong KKY. Long-term pulmonary function after lobectomy for congenital pulmonary airway malformation: is thoracoscopic approach really better than open? J Pediatr Surg. 2018;53(12): 2383–2385.
[18] Wagenaar AE, Tashiro J, Hirzel A, et al. Surgical management of bronchopulmonary malformations. J Surg Res. 2015;198(2):406–412.
[19] Diamond IR, Herrera P, Langer JC, et al. Thoracoscopic versus open resection of congenital lung lesions: a case-matched study. J Pediatr Surg. 2007;42(6):1057–1061.
[20] Bonnard A, Malbezin S, Ferkdadji L, et al. Pulmonary sequestration children: is the thoracoscopic approach a good option? Surg Endosc. 2004;18(9): 1364–1367.
[21] Fiorelli A, Forte S, Caronia FP, et al. Is video-assisted thoracoscopic lobectomy associated with higher overall costs compared with open surgery? Results of best evidence topic analysis. Thorac Cancer. 2021; 12(5):567–579.
[22] Polites SF, Habermann EB, Zarroug AE, et al. Thoracoscopic vs open resection of congenital cystic lung disease – utilization and outcomes in 1120 children in the United States. J Pediatr Surg. 2016;51(7): 1101–1105.
[23] Wagenaar AE, Tashiro J, Satahoo SS, et al. Resection of pediatric lung malformations: National trends in resource utilization & outcomes. J Pediatr Surg. 2016;51(9):1414–1420.
[24] Kapralik J, Wayne C, Chan E, et al. Surgical versus conservative management of congenital pulmonary airway malformation in children: a systematic review and meta-analysis. J Pediatr Surg. 2016;51(3): 508–512.
[25] Khan H, Kurup M, Saikia S, et al. Morbidity after thoracoscopic resection of congenital pulmonary airway malformations (CPAM): single center experience over a decade. Pediatr Surg Int. 2021;37(5):549–554.
[26] Pakkasjärvi N, Taskinen S. Introduction of pediatric robot-assisted pyeloplasty in a low-volume centre. Clin Pract. 2021;11(1):143–150.