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Research Article

# Pediatric Thoracoscopy: Ten Years Experience in Tertiary Hospital

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## Abstract

**Purpose:** A minimally invasive Thoracoscopic Surgery (TS) offers several options in diagnosis and surgical treatment in pediatric surgery. This study evaluates experience and outcome of thoracoscopic surgery in pediatrics during 10 years period in tertiary hospital.

**Patients and methods:** This retrospective study conducted at King Faisal Hospital and Research Center, Jeddah, Saudi Arabia from 2012 to 2022. Data of 43 patients who underwent TS were enrolled. Data include patient's demographic characteristics, co-morbidity, diagnosis, type of thoracoscopic procedures, time of intervention, length of hospital stay, post-operative complications.

**Results:** Mean age of patients was 4.99 years. Females were more than males (55.8 vs. 44.2%). Sixteen (37.2%) patients had comorbidities. Thoracoscopic procedures were feasible in 43 children and adolescents with chest diseases including lung empyema (20.9%), congenital lobar emphysema (14.0%), interstitial lung disease (14.0%), congenital pulmonary airway malformation (11.6%), mediastinal mass (9.3%), lung metastasis (11.6%), lymphoma (4.7%), chronic inflammations (7.0%), hemothorax (2.3%), bronchogenic cyst (2.3%), pleural effusion (2.3%) and pulmonary sequestration and right diaphragmatic hernia (2.3%). Procedures were made mostly for lung biopsy (25.0%), lobectomy (22.7%), decortication (20.9%), mediastinum mass resection (6.8%), lung metastasectomy (6.8%), lymph node biopsy (4.5%), diagnostic (4.6%), cyst excision (4.6%), diaphragmatic hernia repair (2.3%) and thymectomy (2.3%). Duration of hospital stay ranged from 2-180 days. All of the cases had chest drain (100.0%) and some of them required post-operative intubations (30.2%). Conversion rate to open was (4.7%). Complications were pneumothorax (7.0%), bleeding (2.3%) and air leak (2.3%).

**Conclusions:** Thoracoscopic approach is a challenging method for diagnosis and treatment in pediatrics. However, complications were reported as pneumothorax, bleeding and air leak. In order to improve results, conversion rates, and the capacity to handle thoracoscopic complications, proper training is crucial.

**Keywords: Complications; Diagnosis; Pediatrics; Procedures; Thoracoscopic surgery**

## Introduction

Minimally invasive surgery has been heralded as the criterion standard of care for many surgical procedures and in pediatric population; since its initial description [1]. It involves using a small incision to perform surgical procedures, in which minimized unnecessary trauma to surrounding tissue at surgery site [2].

Thoracoscopy was introduced more than a hundred years ago by Swedish physician, Hans Christian Jacobaeus. In 1910, he reported his initial experience after inserting a cystoscope into pleural cavity to make lysis of tuberculous pleural adhesion. But it was not till almost 70 years later in 1976, when Rodgers and Talbert [3], put thoracoscopy into first practical use for pediatric patients. At this early stage, thoracoscopic procedures in children were only limited to lung biopsies, evaluation of pulmonary or thoracic lesions, and regional decortication of an empyema [4]. By mid-1990s thoracoscopic lung biopsy became accepted, and, in many cases, it is a superior approach for obtaining tissue in cases of malignancy or interstitial lung disease [5].

Nowadays, there is an increase in recognition of potential advantages of thoracoscopy worldwide. Its focus on decreasing lung parenchyma damage that will lead to a shorter hospital stay, less wound infection and post-operative pain, less musculoskeletal complications that noted after posterolateral thoracotomy and improved cosmesis after thoracoscopy [6]. Despite increasing recognition of thoracoscopy potential advantages, it did not gain widespread acceptance or popularity owing to technical and anesthetic difficulties [7]. Many pediatric and neonatal surgical conditions approached through a thoracoscopy, including repair of esophageal atresia/tracheoesophageal fistula, congenital diaphragmatic hernia, lung resection and biopsies, treatment of empyema and mediastinal masses [8].

This study aims to identify thoracoscopy usage and outcome in a large variety of pediatric surgical diseases in a single Tertiary hospital during 10 years period and to measure the rate of its complications.

## Materials and Methods

This retrospective study conducted at King Faisal Hospital and Research Center, Jeddah, Saudi Arabia. Data of all patients who underwent thoracoscopy at King Faisal Hospital and Research Center during period from 2012 to 2022 were collected. Excluded from the study were cases referred with complications after primary operation done in another hospital. Data include patient's age, gender,

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presence of co-morbidity, diagnosis, thoracoscopic procedure, time of intervention, time of recovery, length of hospital stay, post-operative complications in follow up within two years. The data collected into excel sheet form medical records. TS were made by rigid 5 mm diameter thoracoscopy (30 degrees, *via* 3 or 4 trocar ports (1.0 cm long skin incision).

### Sample size

Samples included all patients who meet inclusion criteria during period from 2012 to 2022.

### Data analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) (IBM SPSS, IBM Corp., Armonk, N.Y., USA) version 22. The quantitative data presented as mean, standard deviation (minimum - maximum). The categorical data presented frequency and percentage.

## Results

Table 1 showed the demographic characteristics of the patients. The mean age of the studied groups was 4.99 years (SD 4.09). The females were more than males (55.8 *vs.* 44.2%). Sixteen (37.2%) of the patients has comorbidities, of the 5 (11.6%) had malignancy, 3 (7.0%) respiratory distress, 2 (4.7%) CNS diseases, 2 (4.7%) hematological diseases, 1 (2.3%) congenital heart disease, 1 (2.3%) inflammatory disease and 1 (2.3%) leukemia.

The most common diagnosis was lung empyema (n=9, 20.9%), then congenital lobar emphysema (n=6, 14.0%), interstitial lung disease (n=6, 14.0%), congenital pulmonary airway malformation (n=5, 11.6%), mediastinal mass (n=4, 9.3%), lung metastasis (n=5, 11.6%), lymphoma (n=2, 4.7%), chronic inflammation (n=3, 7.0%), hemothorax (n=1, 2.3%), bronchogenic cyst (n=1, 2.3%), pleural effusion (n=1, 2.3%) and pulmonary sequestration and right diaphragmatic hernia (n=1, 2.3%). The operative time range from 22 to 395 min. The procedures were mostly thoracoscopic lung biopsy (25.0%), thoracoscopic lobectomy (22.7%), thoracoscopic decortication (20.9%), thoracoscopic resection of mediastinum mass (6.8%), thoracoscopic lung metastasectomy (6.8%), thoracoscopic lymph node biopsy (4.5%), Diagnostic thoracoscopy (4.6%), thoracoscopic cyst excision (4.6%), thoracoscopic repair of diaphragmatic hernia (2.3%) and thoracoscopic thymectomy (2.3%). Post-operative recovery duration ranges from 24 to 672 hours. Duration of hospital stay ranged from 2-180 days. The chest drain was inserted in all patients (100.0%) with mean duration of chest drain 8.66 days; post-operative intubation required in 13 patients (30.2%) with mean days of intubation was 5.73. The conversion to open in 2 cases (4.7%). Complications were pneumothorax in 3 cases (7.0%), bleeding in one case (2.3%) and air leak in one case (2.3%) (Table 2).

**Table 1:** Demographic characteristics of patient's underwent thoracoscopic procedures (n=43).

| Characteristics | Value |
|---|---|
| Age (years) | 4.99 ± 4.09 (0.08-14.00) |
| **Gender** | |
| Male | 19 (44.2%) |
| Female | 24 (55.8%) |
| **Comorbidity** | |
| No | 27 (62.8%) |
| Yes | 16 (37.2%) |
| Malignancy | 5 (11.6%) |
| Respiratory diseases | 3 (7.0%) |
| Central Nervous System (CNS) diseases | 2 (4.7%) |
| Hematological diseases | 2 (4.7%) |
| Congenital heart disease | 1 (2.3%) |
| Inflammatory disease | 1 (2.3%) |
| Leukemia | 1 (2.3%) |

Data expressed as frequency (%) for categorized data and mean ± standard deviation (minimum-maximum) for parametric data.

## Discussion

Over the last decade thoracoscopy became increasingly important tool in pediatric surgery. The limited explorations, biopsies, and debridement's described by Rodgers in the mid to late 1970s replaced by extensive, technically demanding resections and reconstructive procedures [9]. The results of this study revealed that in our institute over 10 years period thoracoscopy was performed in 43 children and adolescents underwent 44 thoracoscopic procedures as diagnostic and therapeutic strategies for various chest diseases as lung empyema (20.9%), congenital lobar emphysema (14.0%), interstitial lung disease (14.0%), congenital pulmonary airway malformation (11.6%), mediastinal mass (9.34%), lung metastasis (11.6%), lymphoma (4.7%), chronic inflammations (7.0%), hemothorax (2.3%), bronchogenic cyst (2.3%), pleural effusion (2.3%) pulmonary sequestration and right diaphragmatic hernia (2.3%). Due to its technical difficulty, only a few small series have been published and the initial results are encouraging [10-12]. Most studies used thoracoscopy for management of empyema [13-17], pneumothorax [18-20], congenital lung lesions [7,9,21-24],

**Table 2:** Operative characteristics of patient's underwent thoracoscopy procedures (n=43).

| Characteristics | Value |
|---|---|
| **Diagnosis** | |
| Lung empyema | 9 (20.9%) |
| Congenital lobar emphysema | 6 (14.0%) |
| Interstitial lung disease | 6 (14.0%) |
| Congenital pulmonary airway malformation | 5 (11.6%) |
| Mediastina mass | 4 (9.3%) |
| Lung metastatic | 5 (11.6%) |
| Lymphoma | 2 (4.7%) |
| Chronic inflammations | 3 (7.0%) |
| Hemothorax | 1 (2.3%) |
| Bronchogenic cyst | 1 (2.3%) |
| Pleural effusion | 1 (2.3%) |
| Right diaphragmatic hernia with pulmonary sequestration | 1 (2.3%) |
| **Operation time (minutes)** | 133.58 ± 80.57 (22-395) |
| **Thoracoscopic Procedures** | |
| Lung biopsy | 11 (25.0%) |
| Lobectomy | 10 (22.7%) |
| Decortication | 9 (20.9%) |
| Resection of mediastinum mass | 3 (6.8%) |
| Lung metastasectomy | 3 (6.8%) |
| Cyst Excision | 2 (4.7%) |
| Lymph node biopsy | 2 (4.5%) |
| Diagnostic | 2 (4.6%) |
| Diaphragmatic hernia repair | 1 (2.3%) |
| Thymectomy | 1 (2.3%) |
| **Post-operative recovery (hours)** | 132.52 ± 164.99 (24-672) |
| **Duration of hospital stay (days)** | 20.63 ± 30.45 (2-180) |
| Chest drain | 43 (100.0%) |
| Duration of chest drain (days) | 8.66 ± 9.97 (2-45) |
| Intubations | 13 (30.2%) |
| Intubation duration (days) | 5.73 ± 5.41 (1.00-13.00) |
| Convert to open | 2 (4.7%) |
| **Complications** | |
| Pneumothorax | 3 (7.0%) |
| Bleeding | 1 (2.3%) |
| Leak | 1 (2.3%) |

Data expressed as frequency (%) for categorized data and mean ± standard deviation (minimum - maximum) for parametric data.

esophageal atresia with or without trachea-esophageal fistula [10-12,25-30] and congenital diaphragmatic hernia [10,31-40].

Since practically all chest conditions can be treated thoracoscopically, there are neither strict rules against it nor definite advice on which thoracic conditions should or should not be done thus. In this study, the operative time range from 22 min to 395 min. The procedures done were mostly lung biopsy (25.0%), lobectomy (22.7%), decortication (20.9%), resection of mediastinum mass (6.8%), lung metastasectomy (6.8%), lymph node biopsy (4.5%), diagnostic thoracoscopy (4.6%), cyst excision (4.6%), diaphragmatic hernia repair (2.3%) and thymectomy (2.3%). Thoracic empyema was first disease in which the thoracoscopic approach used [41,42]. Following failure of initial conservative therapy with chest tube drainage and antibiotics, early thoracoscopic decortication is advised [43]. Contrary to basic conservative therapy, primary spontaneous pneumothorax treated by thoracoscopic bullectomy without need for extended chest tube drainage and hospitalization [20]. Thoracoscopic lung biopsy is recommended as a day-case operation in some places and utilized as a diagnostic tool for intrathoracic tumors and interstitial lung disease [44]. With the thoracoscopic approach the entire surface of lung and pleura can be evaluated and multiple biopsies can be obtained [45]. Comparing to an open method, thoracoscopic resection of children's anterior and posterior mediastinal lesions provides greater access [46,47]. In comparison to adult lobectomy, thoracoscopy lobectomy is a difficult procedure and more technically demanding. This may be because of the restricted workspace or the complex nature of lung pathology, which carries a risk of bleeding [48]. Albanese and Rothenberg [49] published their experience with 144 consecutive lobectomies in 2007. Of these 144 patients, 141 procedures were done thoracoscopically. Only one intraoperative complication occurred. Average operation time was longer than for conventional open surgery, but hospital stay was shorter (2-8 days). During thoracoscopic lobectomy, Rothenberg et al. [50] reported bleeding (2.67%), air leak (2.67%) and infection (4%); Boubnova et al. [51] reported air leak (6.25%) and phrenic nerve injury (6.25%); Zhang et al. [52] reported conversion to open (0.7%); Rothenberg et al. [50] reported air leak (0.9%) and conversion to open (1.0%); Seong et al. [53] reported bleeding (2.7%), air leak (5.4%) and conversion to open (23.0%). Congenital lobar emphysema, congenital pulmonary adenomatoid malformation, and pulmonary sequestration are among congenital disorders for which lobectomy is indicated; lobectomy for malignant tumors is infrequently done [54,55]. Repair of tracheoesophageal fistula and esophageal atresia can be performed thoracoscopically [27,56,57]. Hemodynamic instability, a low body weight (2 kg), and an inability to tolerate single-lung breathing are all factors that make thoracic closure of esophageal atresia unsuitable for some newborns [58]. An anastomotic stricture (30% to 40%) [45,59] and anastomosis leaking (12% to 22%) are frequent complications but most of these can be treated conservatively [59]. Using a thoracoscopic method, Bochdalek's congenital diaphragmatic hernia is also frequently treated. Due to the underlying pulmonary hypoplasia, the thoracic cavity on the affected side affords excellent working space, for which only very-low-pressure low-flow carbon dioxide insufflation is essential and single-lung ventilation may not be necessary [60]. Thoracoscopy used for primary repair of neonatal hernia either directly or by patch repair [61,62]. Thoracoscopic repair of the neonatal hernia has several drawbacks, namely longer operative time compared to open repair [63], conversion to open repair which ranges from 3% to 14% [64], and recurrence of hernia (from 14% to 21%) [65].

Thoracoscopic procedures are fraught with difficulties, which include a small working space, difficulty in controlling vascular structures, two-dimensional vision and limited tactile feedback, all of which result in a steep learning curve [66]. In this study, post-operative recovery duration ranged from 24 to 672 hours. Duration of hospital stay ranged from 2-180 days. There were no mortalities associated with the thoracoscopic surgical procedures in the present series.

Complications reported during the follow up period in this study were pneumothorax in 3 cases (7.0%), bleeding in one case (2.3%) and air leak in one case (2.3%). A thoracoscopic approach results in decreased postoperative pain, and a superior cosmetic result; the greatest advantage is the avoidance of a formal thoracotomy with its inherent long-term morbidity of scoliosis, shoulder muscle girdle weakness, and chest wall deformity [67]. In addition, the significant decrease in overall wound lengths and tension reduced the risks of wound infection and dehiscence that associated with shorter hospital stays and earlier recovery [68]. Pain is less frequently reported after thoracoscopy compared to thoracotomy, and usually, it is related to port incisions. Local infiltrating anesthesia at the site of trocar insertion before the closure is helpful to control postoperative pain. An intercostal nerve block can also be done under direct visualization at the conclusion of the procedure [8]. Bleeding is of special importance during thoracoscopy because bleeding control can be problematic. Bleeding can be managed either by open conversion or identifying the bleeding site and clipping or cauterization under direct vision. Avoid blind clipping or cauterization as it may lead to serious injury to vital structures [6]. Vigorous manipulation during the extraction of the specimen from the chest cavity should be avoided as it can lead to dissemination of infection or implementation of malignant cells on the chest wall [6]. If postoperative bleeding or air leak are anticipated, insert a chest tube. Otherwise, use suction through the last port and ask the anesthesiologist to keep the lung expanded until the closure is completed [6]. Thoracoscopy is used in different surgical procedures in the pediatric population. Various complications were reported, and careful planning and training are required for better outcomes.

## Limitations

The retrospective nature is one limitation due to restriction of getting all data about the patients and management of the developed complications. Another limitation of this study was the absence of a control population of children managed by using a thoracotomy. However, a true comparative trial would most likely be impossible owing to the overwhelming acceptance of minimal access techniques for children.

## Conclusions

Thoracoscopic approach is a challenging method in the diagnosis and treatment of children and adolescent's pulmonary diseases. The long-term benefit of this technique is that it spares growing children from a thoracotomy procedure that has the potential for late musculoskeletal morbidity none of which was noted in this series, decreased operation time, duration of hospital stays and decreased wound infection. However, many complications were reported pneumothorax, bleeding and air leak. Proper training is essential as it affects the outcomes and conversion rate and enhances the ability to manage the complications thoracoscopically. Conversion should not be considered as treatment failure, and its possibility should be explained to the patients/parents and stated clearly in the consent.

## References


1. Albanese CT, Sydorak RM, Tsao K, Lee H. Thoracoscopic lobectomy for prenatally diagnosed lung lesions. J Pediatr Surg. 2003;38(4):553-5.
2. Tobias JD. Thoracoscopy in the pediatric patient. Anesthesiology clin North America. 2001;19(1):173-86.
3. Rodgers BM, Talbert JL. Thoracoscopy for diagnosis of intrathoracic lesions in children. J Pediatr Surg. 1976;11(5):703-8.
4. Rodgers BM. Pediatric thoracoscopy: where have we come and what have we learned? Ann Thorac Surg. 1993;56(3):704-7.
5. Rothenberg SS. Thoracoscopic lung resection in children. J Pediatr Surg. 2000;35(2):271-5.
6. Bawazir OA. Thoracoscopy in pediatrics: Surgical perspectives. Ann Thorac Med. 2019;14(4):239-47.
7. Rahman N, Lakhoo K. Comparison between open and thoracoscopic resection of congenital lung lesions. J Pediatr Surg. 2009;44(2):333-6.
8. Ahmad NS, Dobby N, Walker E, Sogbodjor LA, Kelgeri N, Pickard A, et al. A multicenter audit of the use of bronchoscopy during open and thoracoscopic repair of esophageal atresia with tracheoesophageal fistula. Paediatr Anaesth. 2019;29(6):640-7.
9. Lau CT, Leung J, Hui TW, Wong KKY. Thoracoscopic operations in children. Hong Kong Med J. 2014;20:234-40.
10. Szavay PO, Zundel S, Blumenstock G, Krischner HJ, Luithle T, Girisch M, et al. Perioperative outcome of patients with esophageal atresia and tracheo-esophageal fistula undergoing open versus thoracoscopic surgery. J Laparoendosc Adv Surg Tech A. 2011;21(5):439-43.
11. Huang J, Tao J, Chen K, Dai K, Tao Q, Chan IHY, et al. Thoracoscopic repair of oesophageal atresia: experience of 33 patients from two tertiary referral centres. J Pediatr Surg. 2012;47(12):2224-7.
12. Allal H, Perez-Bertolez S, Maillet O, Forgues D, Doan Q, Chiapinelli A, et al. [Comparative study of thoracoscopy versus thoracotomy in esophageal atresia]. Cir Pediatr. 2009;22(4):177-80.
13. Aziz A, Healey JM, Qureshi F, Kane TD, Kurland G, Green M, et al. Comparative analysis of chest tube thoracostomy and video-assisted thoracoscopic surgery in empyema and parapneumonic effusion associated with pneumonia in children. Surg Infect (Larchmt). 2008;9(3):317-23.
14. Freitas S, Fraga JC, Canani F. Thoracoscopy in children with complicated parapneumonic pleural effusion at the fibrinopurulent stage: a multi-institutional study. J Bras Pneumol. 2009;35(7):660-8.
15. Padman R, King KA, Iqbal S, Wolfson PJ. Parapneumonic effusion and empyema in children: retrospective review of the duPont experience. Clin Pediatr (Phila). 2007;46(6):518-22.
16. Peter SDS, Tsao K, Spilde TL, Keckler SJ, Harrison C, Jackson MA, et al. Thoracoscopic decortication vs tube thoracostomy with fibrinolysis for empyema in children: a prospective, randomized trial. J Pediatr Surg. 2009;44(1):106-11.
17. Tsao K, St Peter SD, Sharp SW, Nair A, Andrews WS, Sharp RJ, et al. Current application of thoracoscopy in children. J Laparoendosc Adv Surg Tech A. 2008;18(1):131-5.
18. Bialas RC, Weiner TM, Phillips JD. Video-assisted thoracic surgery for primary spontaneous pneumothorax in children: is there an optimal technique? J Pediatr Surg. 2008;43(12):2151-5.
19. Choi SY, Kim YH, Jo KH, Kim CK, Park JK, Cho DG, et al. Video-assisted thoracoscopic surgery for primary spontaneous pneumothorax in children. Pediatr Surg Int. 2013;29(5):505-9.
20. Chung PH, Wong KK, Lan LC, Tam PKH. Thoracoscopic bullectomy for primary spontaneous pneumothorax in pediatric patients. Pediatr Surg Int. 2009;25(9):763-6.
21. Bonnard A, Malbezin S, Ferkdadji L, Luton D, Aigrain Y, de Lagauise P. Pulmonary sequestration children: is the thoracoscopic approach a good option? Surg Endosc. 2004;18(9):1364-7.
22. Diamond IR, Herrera P, Langer JC, Kim PCW. Thoracoscopic versus open resection of congenital lung lesions: a case-matched study. J Pediatr Surg. 2007;42(6):1057-61.
23. Kunisaki SM, Powelson IA, Haydar B, Browshier BC, Jarboe MD, Mychaliska GB, et al. Thoracoscopic vs open lobectomy in infants and young children with congenital lung malformations. J Am Coll Surg. 2014;218(2):261-70.
24. Vu LT, Farmer DL, Nobuhara KK, Miniati D, Lee H. Thoracoscopic versus open resection for congenital cystic adenomatoid malformations of the lung. J Pediatr Surg. 2008;43(1):35-9.
25. Al Tokhais T, Zamakhshary M, Aldekhayel S, Mandora H, Sayed S, AlHarbi K, et al. Thoracoscopic repair of tracheoesophageal fistulas: a case-control matched study. J Pediatr Surg. 2008;43(5):805-9.
26. Dingemann C, Ure B, Dingemann J. Thoracoscopic procedures in pediatric surgery: what is the evidence? Eur J Pediatr Surg. 2014;24(1):14-9.
27. Holcomb GW, 3rd, Rothenberg SS, Bax KM, Martinez-Ferro M, Albanese CT, Ostlie DJ, et al. Thoracoscopic repair of esophageal atresia and tracheoesophageal fistula: a multi-institutional analysis. Ann Surg. 2005;242(3):422-8.
28. MacKinlay GA. Esophageal atresia surgery in the 21st century. Semin Pediatr Surg. 2009;18(1):20-2.
29. Rothenberg SS. Thoracoscopic repair of esophageal atresia and tracheoesophageal fistula in neonates, first decade's experience. Dis Esophagus. 2013;26(4):359-64.
30. van der Zee DC, Tytgat SH, Zwaveling S, van Herwaarden MY, Vieira-Travassos D. Learning curve of thoracoscopic repair of esophageal atresia. World J Surg. 2012;36(9):2093-7.
31. Becmeur F, Reinberg O, Dimitriu C, Moog R, Philippe P. Thoracoscopic repair of congenital diaphragmatic hernia in children. Semin Pediatr Surg. 2007;16(4):238-44.
32. Cho SD, Krishnaswami S, McKee JC, Zallen G, Silen ML, Bliss DW. Analysis of 29 consecutive thoracoscopic repairs of congenital diaphragmatic hernia in neonates compared to historical controls. J Pediatr Surg. 2009;44(1):80-6.
33. Fishman JR, Blackburn SC, Jones NJ, Madden N, Caluwe DD, Haddad MJ, et al. Does thoracoscopic congenital diaphragmatic hernia repair cause a significant intraoperative acidosis when compared to an open abdominal approach? J Pediatr Surg. 2011;46(3):458-61.
34. Gander JW, Fisher JC, Gross ER, Reichstein AR, Cowles RA, Aspelund G, et al. Early recurrence of congenital diaphragmatic hernia is higher after thoracoscopic than open repair: a single institutional study. J Pediatr Surg. 2011;46(7):1303-8.
35. Gomes Ferreira C, Reinberg O, Becmeur F, Allal H, De Lagausie P, Lardy H, et al. Neonatal minimally invasive surgery for congenital diaphragmatic hernias: a multicenter study using thoracoscopy or laparoscopy. Surg Endosc. 2009;23(7):1650-9.
36. Keijzer R, van de Ven C, Vlot J, Sloots C, Madern G, Tibboel D, et al. Thoracoscopic repair in congenital diaphragmatic hernia: patching is safe and reduces the recurrence rate. J Pediatr Surg. 2010;45(5):953-7.
37. Kim AC, Bryner BS, Akay B, Geiger JD, Hirschl RB, Mychaliska GB. Thoracoscopic repair of congenital diaphragmatic hernia in neonates: lessons learned. J Laparoendosc Adv Surg Tech A. 2009;19(4):575-80.
38. Lao OB, Crouthamel MR, Goldin AB, Sawin RS, Waldhausen JH, Kim SS. Thoracoscopic repair of congenital diaphragmatic hernia in infancy. J Laparoendosc Adv Surg Tech A. 2010;20(3):271-6.
39. McHoney M, Giacomello L, Nah SA, Coppi PD, Kiely EM, Curry JI, et al. Thoracoscopic repair of congenital diaphragmatic hernia: intraoperative ventilation and recurrence. J Pediatr Surg. 2010;45(2):355-9.
40. Okazaki T, Nishimura K, Takahashi T, Shoji H, Shimizu T, Tanaka T, et al. Indications for thoracoscopic repair of congenital diaphragmatic hernia in neonates. J Pediatr Surg. 2011;27(1):35-8.
41. Dorman RM, Vali K, Rothstein DH. Trends in treatment of infectious parapneumonic effusions in U.S. children's hospitals, 2004-2014. J Pediatr Surg. 2016;51(6):885-90.
42. Livingston MH, Colozza S, Vogt KN, Merritt N, Bütter A. Making the transition from

video-assisted thoracoscopic surgery to chest tube with fibrinolytics for empyema in children: Any change in outcomes? Can J Surg. 2016;59(3):167-71.

43. Islam S, Calkins CM, Goldin AB, Chen C, Downard CD, Huang EY, et al. The diagnosis and management of empyema in children: a comprehensive review from the APSA Outcomes and Clinical Trials Committee. J Pediatr Surg. 2012;47(11):2101-10.

44. Nadlonek NA, Acker SN, Deterding RR, Partrick DA. Intraoperative chest tube removal following thoracoscopic lung biopsy results in improved outcomes. J Pediatr Surg. 2014;49(11):1573-6.

45. Van Niekerk ML. Paediatric thoracoscopy: State of the art. S Afr J Surg. 2011;49(1):33-5.

46. Souzaki R, Kawakubo N, Miyoshi K, Obata S, Kinoshita Y, Takemoto J, et al. The Utility of Muscle-Sparing Axillar Skin Crease Incision with Thoracoscopic Surgery in Children. J Laparoendosc Adv Surg Tech A. 2018;28(11):1378-82.

47. Scarpa AA, Ram AD, Soccorso G, Singh M, Parikh D. Surgical Experience and Learning Points in the Management of Foregut Duplication Cysts. Eur J Pediatr Surg. 2018;28(6):515-21.

48. Rothenberg SS. First decade's experience with thoracoscopic lobectomy in infants and children. J Pediatr Surg. 2008;43(1):40-4; discussion 45.

49. Albanese CT, Rothenberg SS. Experience with 144 consecutive pediatric thoracoscopic lobectomies. J Laparoendosc Adv Surg Tech A. 2007;17(3):339-41.

50. Rothenberg SS, Kuenzler KA, Middlesworth W, Kay S, Yoder S, Shipman K, et al. Thoracoscopic lobectomy in infants less than 10 kg with prenatally diagnosed cystic lung disease. J Laparoendosc Adv Surg Tech A. 2011;21(2):181-4.

51. Boubnova J, Peycelon M, Garbi O, David M, Bonnard A, De Lagausie P. Thoracoscopy in the management of congenital lung diseases in infancy. Surg Endosc. 2011;25(2):593-6.

52. Zhang J, Yuan M, Xu C, Yang G, Li F. [Clinical Report of 128 Cases of Meticulous Thoracoscopic Lobectomy in Children]. Sichuan Da Xue Xue Bao Yi Xue Ban. 2018;49(3):474-7.

53. Seong YW, Yoo BS, Kim JT, Park IK, Kang CH, Kim YT. Video-assisted thoracoscopic lobectomy in children: safety and efficacy compared with the conventional thoracotomy approach. Innovations (Phila). 2012;7(6):394-8.

54. Moyer J, Lee H, Vu L. Thoracoscopic Lobectomy for Congenital Lung Lesions. Clin Perinatol. 2017;44(4):781-94.

55. Park S, Kim ER, Hwang Y, Lee HJ, Park IK, Kim YT, 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):3932-8.

56. Wu Y, Kuang H, Lv T, Wu C. Comparison of clinical outcomes between open and thoracoscopic repair for esophageal atresia with tracheoesophageal fistula: a systematic review and meta-analysis. Pediatr surg int. 2017;33(11):1147-57.

57. Rothenberg SS. Thoracoscopic repair of tracheoesophageal fistula in newborns. J Pediatr Surg. 2002;37(6):869-72.

58. Rothenberg SS. Thoracoscopy in infants and children: the state of the art. J Pediatr Surg. 2005;40(2):303-6.

59. Patkowski D, Rysiakiewicz K, Jaworski W, Zielinska M, Siejka G, Konsur K, et al. Thoracoscopic repair of tracheoesophageal fistula and esophageal atresia. J Laparoendosc Adv Surg Tech A. 2009;19(Suppl 1):19-22.

60. Lansdale N, Alam S, Losty PD, Jesudason EC. Neonatal endosurgical congenital diaphragmatic hernia repair: a systematic review and meta-analysis. Ann Surg. 2010; 252(1):20-6.

61. Poupalou A, Vrancken C, Vanderveken E, Steyaert H. Use of Nonabsorbable Spiral Tacks for Mesh Reinforcement in Thoracoscopic Repair of Congenital Diaphragmatic Hernia. Eur J Pediatr Surg Rep. 2018;6(1):e27-31.

62. Bruns NE, Glenn IC, McNinch NL, Arps K, Ponsky TA, Schlager A. Approach to Recurrent Congenital Diaphragmatic Hernia: Results of an International Survey. J Laparoendosc Adv Surg Tech A. 2016;26(11):925-9.

63. Esposito C, Mattioli G, Monguzzi GL, Montinaro L, Riccipetiotoni G, Messina M, et al. Complications and conversions of pediatric videosurgery: the Italian multicentric experience on 1689 procedures. Surg Endosc. 2002;16(5):795-8.

64. Marhuenda C, Guillén G, Sánchez B, Urbistondo A, Barceló C. Endoscopic repair of late-presenting Morgagni and Bochdalek hernia in children: case report and review of the literature. J Laparoendosc Adv Surg Tech A. 2009;19(Suppl 1):S95-101.

65. Guner YS, Chokshi N, Aranda A, Ochoa C, Qureshi FG, Nguyen NX, et al. Thoracoscopic repair of neonatal diaphragmatic hernia. J Laparoendosc Adv Surg Tech A. 2008;18(6):875-80.

66. Rothenberg SS. Experience with thoracoscopic lobectomy in infants and children. J Pediatr Surg. 2003;38(1):102-4.

67. Lau CT, Leung L, Chan IH, Chung PHY, Lan LCL, Chan KL, et al. Thoracoscopic resection of congenital cystic lung lesions is associated with better post-operative outcomes. Pediatr Surg Int. 2013;29(4):341-5.