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The benefits of VATS technique for diagnostic and treatment of paediatric thoracic problems

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Abstract
Background: A minimally invasive surgery such as video-assisted thoracic surgery (VATS) has been used for diagnostic and therapeutic procedure in children for the last decade. This study described the VATS surgical technique used in the treatment of pediatric thoracic cases and highlighted the benefit of surgical treatment for thoracic problems in pediatric, mainly in empyema thoracis, pneumothorax, and congenital diaphragmatic hernia.
Result: We used thoracoscopic approach, which is video-assisted thoracic surgery (VATS) as the surgical approach for cases such as recurrent primary spontaneous pneumothorax (PSP), recurrent empyema thoracis, and congenital diaphragmatic hernia (CDH) in our institution. All children received general anaesthesia. Selective ventilation of the left or right bronchus was used to allow ipsilateral lung collapse for better visualization. The patient was positioned in swimmer position or lateral decubitus position with the ipsilateral side up and in a slight reverse Trendelenburg position. A 5 mm incision was made on the ipsilateral of the apex of scapula, and a 5 mm trocar was used. For empyema thoracis we used two trocars, which were 5 mm for camera and 3 mm trocar. The fibrotic tissue was excised and the pleural space was debrided. In recurrent pneumothorax case, we used the 5mm trocar for the camera. An fibrotic tissue excision was done to facilitate better drainage for the chest tube. We used the VATS approach for the CDH case in a full-term neonates, using 5 mm and 3 mm trocars with low flow insufflation.
Conclusion: The use of minimally invasive surgery such as video-assisted thoracoscopic surgery can be a valuable choice in the management of selected thoracic conditions. There is evidence that VATS provides an advantage compared to thoracotomy. It is beneficial to minimalized the surgical wound and shortened the time of operation.

Keywords: Minimally invasive surgery, video-assisted thoracoscopic surgery, congenital diaphragmatic hernia, empyema, pneumothorax

1. Introduction
In the 1990s, the advancement of video-assisted thoracoscopic surgery (VATS) provided clinicians with a new approach that allowed mechanical debridement and drainage of the pleural cavity without the need for a thoracotomy [1]. According to a systematic review done in 2005, primary VATS was associated with better outcomes than nonoperative management [2]. Approximately 10% to 15% of paediatric patients undergoing major thoracotomies will have chest wall deformity, muscle injury or scoliosis. In comparison, most VATS procedures can be done with three or four 3–5 mm ports and a small working incision if necessary, significantly reducing chest wall morbidities and providing a better cosmetic result [3, 4]. This study highlighted the benefit of surgical treatment for thoracic problems in pediatric, mainly in empyema thoracis, pneumothorax, and congenital diaphragmatic hernia.

2. Case Report
2.1 Case 1. Empyema Thoracis Dextra gr. II-III on WSD tube insertion with pulmonary tuberculosis
A 15-year-old boy was admitted to the ER with a chief complaint of shortness of breath with cough since 2 months before admission. He had a 11 kg weight loss in a period of 2 months. He was on pulmonary tuberculosis treatment since 3 months before admission, and had a history of right pleural effusion and on WSD chest tube since 3 months prior. He also had a history of chronic heart failure with dilated cardiomyopathy. Other symptoms such as fever, chest pain, diarrhea, vomiting, or rash were denied.

On admission, he had dyspnea and was slightly tachypneic with tachycardia and decreasing O_2 saturation. His vesicular breath sound was diminished with amphoric sound on right side of the lung and rhonchi on both side of the lungs. Water Seal Drainage (WSD) chest tube insertion had already inserted with pus product of 50-70cc every 24 hours. He was on pulmonary tuberculosis treatment for 3 months but the pus was still produced. The WSD chest tube insertion was not efficient enough to drain the empyema, after more than 30 days with the chest tube and recurrent production of the pus.

Laboratory findings on admission were, hemoglobin 10.6/g/dL, thrombocytes $91/10^3/\mu L$, albumin 2.3 g/dL, SGOT 45 U/L, SGPT 15 U/L. We had done blood culture and resistance but there was not any organism growth. On chest radiograph finding, there was loculated empyema showed on the right side of the lung (Fig. 1). Thoracal CT scan was performed (Fig. 2) showing a right hydropneumothorax, atelectasis and bronchiectasis on the right lung and multiple nodes with cavities on the left lung, with a WSD chest tube inserted on the right hemithorax.

Following the CT, diagnostic laparoscopy was performed with a plan to drainage the empyema. The patient was position in swimmer left lateral decubitus (Fig. 3). The incisions were done in the level of 3rd intercostal space to insert a 5 mm trocar for the camera. Other incisions were made on 7th intercostal space in line with posterior axillary line for 3 mm trocar (Fig. 4). The right thoracal cavity showed pus and fibrotic tissue, showing a grade III empyema thoracis (Fig. 5). We then excised the fibrotic tissue manually then drainage the thoracal cavity with 0.9% sodium chloride. Post operatively, the patient was admitted in PICU for 3 days, and was extubated less than 24 hours. The WSD chest tube was released 9 days after the VATS procedure. Post-operatively, we found a resolution for the empyema thoracis. We had done a follow-up chest radiograph and found the opacity decreasing less than 1/3 of right hemithorax.

Fig 1: Chest Radiograph showing right empyema thoracis

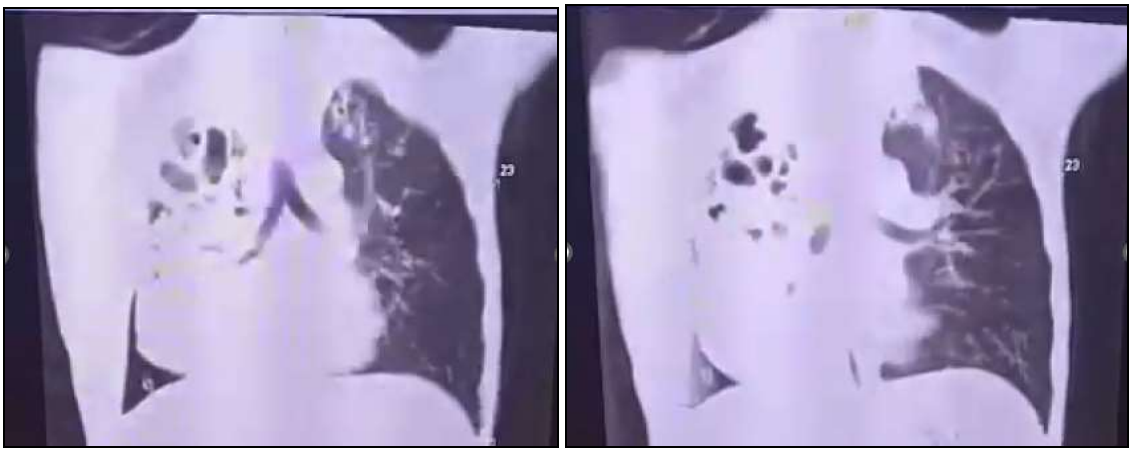

Fig 2: Thorax CT Scans showing atelectasis with bronchiectasis in the right lung

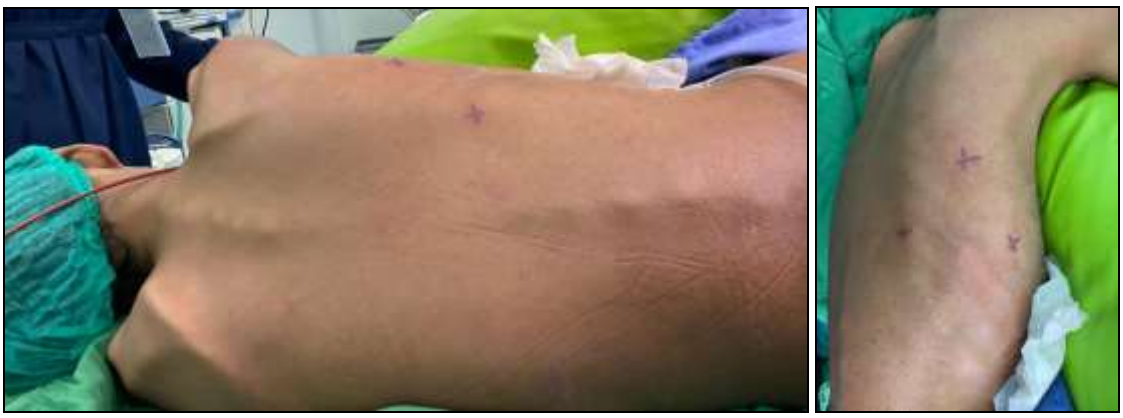

Fig 3: Pre-operative preparation and patient's positioning

Fig 4: Trocar placement for VATS procedure

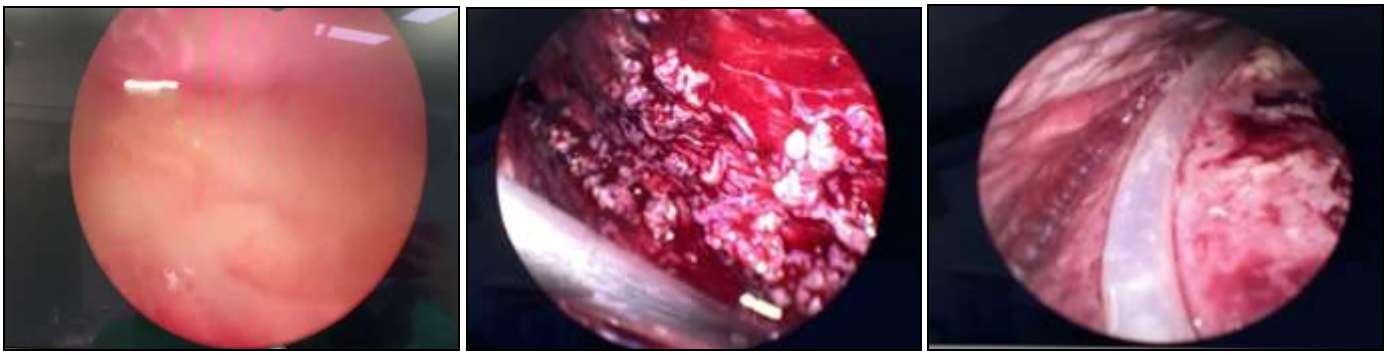

Fig 5: Intraoperative findings showing empyema thoracis grade III

2.2 Case 2. Primary Left Spontaneous Pneumothorax grade I with inadequate WSD tube insertion

A child aged 2 months was admitted to the ER with a chief complaint of shortness of breath after previously was choked while she was drinking milk. She had a history of fever 2 days before the admission and diarrhea with profuse vomiting and cough. She was then diagnosed with severe bronchopneumonia by the pediatrician and then was admitted to PICU.

At the time the patient was consulted to the pediatric surgery, the patient had been failed to wean the respiratory ventilation. The child had tachypnea with hyperthermia. She had intercostal retraction on both side of the chest and diminished vesicular breath sound. Rhonchi was hear on the left side of the chest. Laboratory findings showed hemoglobin 10.7/g/dL, and leukocytosis $16.90x10^9$/L. The radiological findings showed left pneumothorax on the chest radiograph (Fig. 6). Insertion of the WSD chest tube was done first in the ER before the PICU admission, then 2 times after 3 days post-insertion in PICU then 11 days after, because of the inadequate drainage.

Diagnostic laparoscopy was done to diagnose and treat the recurrent pneumonia. The patient was positioned in swimmer right lateral decubitus with the incision on the apex of the scapula in the 5^{th} intercostal space to insert a 5 mm trocar for the camera. The left thoracic cavity was identified, and we found a pleural fibrotic tissue and the WSD chest tube was located extrapleural (Fig. 7). We then excised the fibrotic tissue and revised the position of the chest tube. We evaluate the WSD chest tube and the undulation was present.

Fig 6: Chest Radiograph showing left pneumothorax

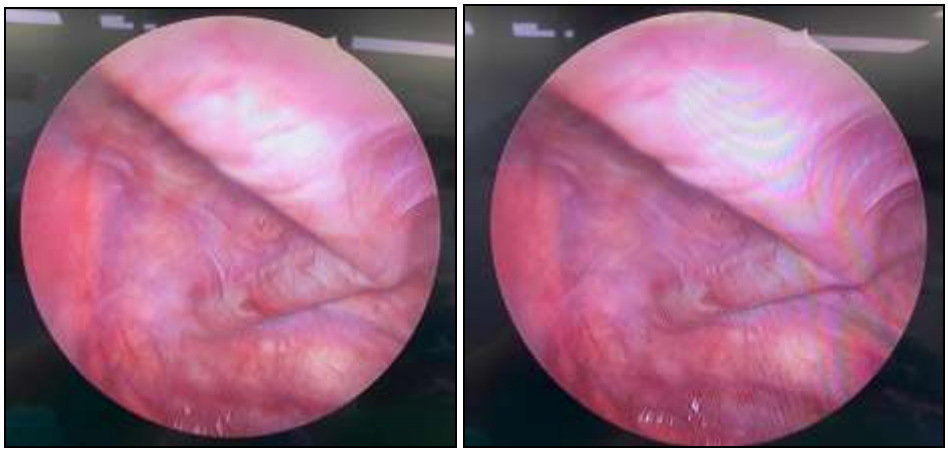

Fig 7: Intraoperative finding showing the extrapleural location of the WSD chest tube, causing inadequate pneumothorax drainage

2.3 Case 3. Left Congenital Diaphragmatic Hernia

Three neonates ranging from 11 days old to 1 month had been diagnosed with congenital diaphragmatic hernia in our center study. They came to the ER with a chief complaint of shortness of breath, with vomiting every feeding and inadequate breastfeeding. Temperature instability and cough were denied.

On thoracal physical examination, we found a retraction of the chest wall with a diminished vesicular breath sound on the left chest, with a peristaltic sound on it. The chest radiograph showed opacification of left sided hemithorax, suggesting an intestinal loop in the left hemithorax (Fig. 10).

Following the diagnosis, we performed VATS for the diagnostic and treatment of Congenital Diaphragmatic Hernia. We positioned the patients with swimmer right lateral decubitus. The incision was done in the apex of scapula on the level of SIC V to insert a 5 mm trocar for the camera. Other incision were made on the level of SIC VII posterior axillary line and posterior midclavicular line to insert two 3 mm trocars (Fig. 9). We identified the left side hemithorax and found all of the intestinal, spleen, and the left lobe of liver was located in the left side of the thoracal cavity. The gastrointestinal contents were returned back to the abdominal cavity and the hernia ring was sutured with a 3.0 prolene extracorporeally. A 8mm gastric tube was inserted as a WSD chest tube for drainage.

Fig 8: Chest Radiograph showing left congenital diaphragmatic hernia

Fig 9: Pre-operative preparation and positioning, with trocar placement for VATS

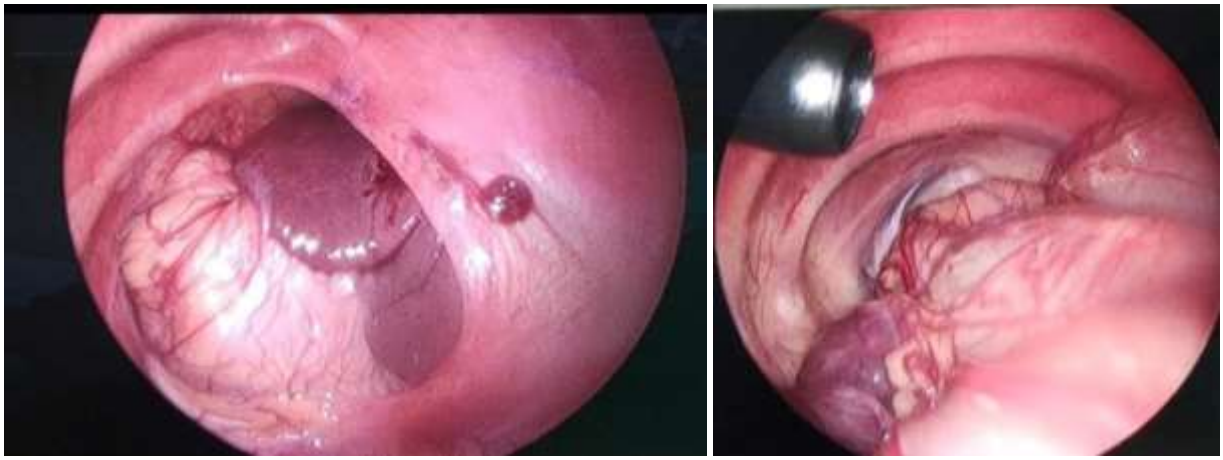

Fig 10: Intraoperative findings showing herniated intestinal, spleen, and the left lobe of liver in the left side of the thoracal cavity

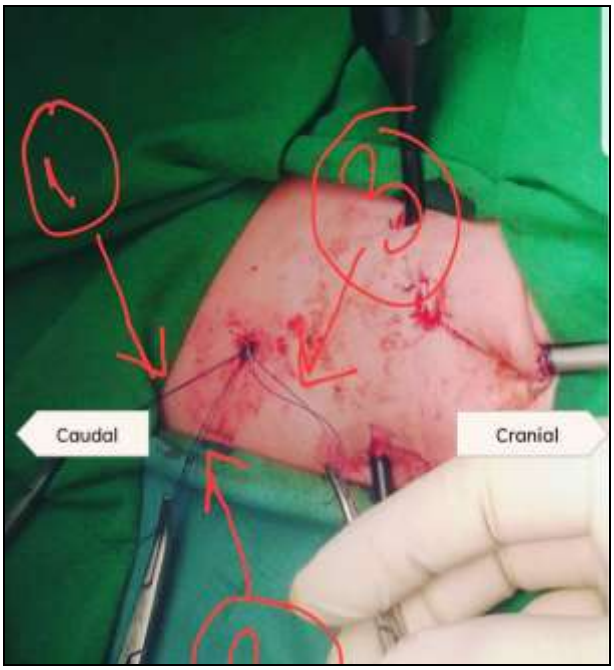

Fig 11: Post-operative suture

Fig 12: Post-operative Chest Radiograph

3. Discussion

3.1 Empyema Thoracis

The early aim objective in the treatment of empyema is to prevent sepsis and eliminate fever by evacuation and sterilization of the pleural cavity, as well as ensuring lung reexpansion and restoration of lung function, whereas the long-term aim objective is to prevent lung damage. To achieve this goal, early and prompt surgical treatment is required. Earlier debridement yields better result, with the indication of surgical intervention depends on the stage of the disease and surgeon's preference. A meta-analysis study done by Avansino *et al*. in Washington, concluded primary operative therapy is associated with lower in-hospital mortality rate, reintervention rate, length of stay, time with tube thoracostomy, and time of antibiotic therapy, compared with nonoperative management [2]. An observational study conducted in Pakistan by Majeed *et al*., early surgical treatment gives satisfactory results in management of paediatric empyema, and VATS is a safe alternative to open thoracotomy with less incidence of complication and postoperative morbidity and mortality [5]. A study done by Mackinlay *et al*. compared 31 patients with 33 patients treated with thoracotomy in the VATS-treated fibrinopurulent phase. The result stated VATS has the same rate of success as open thoracotomy but offer advantages in terms of the resolution of the disease, hospital stay, and cosmetic result [6].

In this study, we use VATS in the management of 3rd stage of thoracic empyema or organizing phase. A study done in Poland in 2021 by Barglik *et al*. indicates that the thoracoscopic procedure is safely feasible for the management of 3rd stage pleural empyema and should be considered as the preferred approach. The post-operative stay and general course of the disease are milder with early surgery management without prolonged conservative treatment attempt. Complete excision of the fibrotic tissue that are trapping the lung is critical in the surgical intervention in the third phase of empyema thoracis, so complete re-expansion of the lung can occur and reducing the risk of reinfection incidence. Entrapped lung prone to reduce the effectiveness of the antibiotics, because the reduced of tissue perfusion of the lung [7]. Cohort studies in adult cases presented similar findings, with expert consensus statement of the European Association for Cardio-Thoracic Surgery (EACTS) has recommended primary VATS procedure for the surgical management procedure, including the organized phase [8–11].

3.2 Recurrent Pneumothorax

The indications for surgical approach for Primary Spontaneous Pneumothorax (PSP) include persistent air leak, recurrent PSP,

contralateral PSP, and PSP in high-risk occupations such as being a pilot or a diver [12]. The aim of the surgical approach for PSP are closure of the air leak and preventing recurrent incidence. One of the surgical technique mostly used is the minimally invasive VATS technique. In a study conducted in Kuwait by Ayed *et al*. for patients underwent VATS for PSP, recurrent pneumothorax was the most frequent indication for surgery. On thoracoscopic findings, clear bullae were found in types II and III with 67 cases (71%), type II pleuropulmonary adhesions were identified in 15 cases (16%), and in 12 cases (13%) any abnormality was not found (type I) [12]. In our study, the thoracoscopic finding failed to identified any abnormalities. According to Ayed *et al*., persistent air leak occurred in 4 out of 12 patients in type I. Longer pleural drainage and postoperative hospital stay was found in type I compared to other types. The study indicated that simple apical excision and apical pleurectomy in these cases are not sufficient and perhaps needs additional talc poudrage which induce pleural symphysis [12].

In our study, we used single 5 mm port for the thoracoscopic procedure. A study conducted by Do Kyun Kang *et al*. in Korea compared patients underwent three-ports VATS technique and single-port VATS technique. The results state the mean lengths of chest tube drainage and hospital stay were shorter in single-port technique than in the three-port group. Postoperative pain and paresthesia in the single-port group was statistically less significant than in the three-port group [13].

A single center study in Indiana conducted by Tragesser *et al*., found that early VATS was associated with reduced overall recurrence (P<0.001), admissions (P<0.001), cumulative chest x-rays (P=0.043), and cumulative hospital length of stay (P=0.022) compared to late VATS [14]. Early surgical treatment, within 48 hours, has been suggested to improve the outcomes of recurrent pneumothorax in the paediatric population compared to adults [15, 16].

3.3 Congenital Diaphragmatic Hernia

Laparotomy is the traditional surgical management of congenital diaphragmatic hernia (CDH), but studies reported that the used of minimally invasive surgery has been increasing in the last decade, including laparoscopic and thoracoscopic surgery [17]. In our case, oral feeding was started in day 3 post operation day, and the baby was discharged in 8 days. A systematic literature review conducted in Germany by Kiblawi *et al*. reported many advantages and disadvantages of the thoracoscopic approach in thoracic problems, including CDH. The advantages of VATS in CDH cases includes shorter hospital stay, shorter postoperative ventilation after VATS repair, and faster time to oral feeding, whereas the disadvantages are longer operative time, recurrence, and hypercapnia and acidosis intraoperative [18].

In our case, we had minimal blood loss for thoracoscopic approach for repairing congenital diaphragmatic hernia, which was 10 ml. A study conducted in Japan by Tanaka *et al*. in 2013 comparing open repair with thoracoscopic repair, it was reported that thoracoscopic repair intraoperative haemorrhage was significantly less than open repair [19]. Other study comparing complications and outcomes in open approach by laparotomy and thoracotomy with thoracoscopic approach by laparoscopic and thoracoscopic reported that minimally invasive approach to CDH repair is associated with an increased rate of diaphragmatic hernia recurrence, a decreased rate if early adhesive small bowel disease requiring operation, and a decreased length of initial inpatient hospital length of stay, when stratified by diaphragmatic defect size using CDHSG Staging System [20].

4. Conclusions

The use of minimally invasive surgery such as video-assisted thoracoscopic surgery can be a valuable choice in the management of selected thoracic conditions. There is evidence that VATS provides an advantage compared to thoracotomy. It is beneficial to minimalized the surgical wound and shortened the time of operation.

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6. Conflict of Interest

Not available

7. Financial Support

Not available

10. References

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