Case Series

Anesthetic Challenges During Video-Assisted Thoracoscopic Surgeries for Pediatric Empyema Thoracis: A Case Series

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Abstract

Video-assisted thoracoscopic surgery (VATS) is a less invasive approach for thoracoscopic surgery providing better visualization through minimal access. In addition, it offers less postoperative pain, fewer operative complications, and shortened hospital stay. These advantages make VATS ideal for the pediatric age group. Various societies recommend the use of VATS for Stage 2 pulmonary empyema and also in some cases of early Stage 3 where the plane of cleavage exists between the pleura and the exudate. A well-executed one-lung ventilation (OLV) is necessary for a successful VATS; however, performance of OLV and postoperative pain management in children poses a challenging task for an anesthesiologist.

Keywords: Empyema thoracic, one-lung ventilation, pain postoperative, pediatric, video-assisted thoracoscopic surgery

Introduction

Empyema is defined as pus in the pleural space and can affect any age group, sex, and ethnicity. There is an increasing incidence both in developing and developed countries. It is one of the major health issues in developing countries due to low socioeconomic status, malnutrition, delay in diagnosis, and referral to higher centers.[1] A study by Singh *et al*. shows an increased incidence between May and August every year, i.e., summer and rainy season. *Staphylococcus aureus* is the most common cause in developing countries, while *Streptococcus pneumonia* is the leading cause in developed nations. The evaluation depends on the clinical presentation of the child and stage of the illness, which is best assessed by a recent contrast-enhanced computed tomography (CECT) scan of the chest showing the extent of involvement. Exudative phase (Stage 1) is amenable to conservative management with antibiotics and thoracostomy tube. If the clinical condition worsens with signs of sepsis, then it is an indication for surgical intervention. Fibrinopurulent stage (Stage 2) is characterized by thickened fluid with fibrinous strands and loculations. Despite thoracostomy tube, the drainage may not be complete with incomplete expansion of the lungs. High suspicion of migration into the organizing stage (Stage 3) looms large in the presence of unabated symptoms with deterioration in the clinical condition. Video-assisted thoracoscopic surgery (VATS) has been recommended early in the Stage 2 for both diagnosis and a therapeutic option.[2] According to Menon *et al*., VATS is associated with lower postoperative hospital stay, shorter duration of chest drainage, and greater improvement in subjective dyspnea.[3] Decortication remains the method of choice during organized/organizing parapneumonic effusion.[2,3] We present anesthetic considerations and management of four cases of empyema thoracis done during the year 2019.

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Case Reports

Case 1

A 4½-year-old female child weighing 15 kg presented with fever, cough, coryza, and pain on the left side of the chest.

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Clinically, a dull note was found over the left side of the chest and auscultation revealed a decreased air entry as well with bronchial breath sounds in the axillary and intrascapular area. X-ray chest showed large pleural effusion with mediastinal displacement [Figure 1]. Noncontrast CT chest revealed destroyed left lower lobe along with varicose and cystic bronchiectasis and left hydropneumothorax [Figure 2]. Surgery planned was VATS and proceed under general anesthesia (GA). Parents were explained about the procedure and informed consent was obtained. Preoperative intravenous (IV) access was secured, after application of EMLA cream (Eutectic mixture of Lignocaine and Prilocaine). On arrival at operation theater (OT), the child was co-induced in the parental presence with IV fentanyl (2 mcg/kg) and propofol (2 mg/kg). Muscle relaxant, IV atracurium (0.5 mg/kg) was administered after the confirmation of adequate bag and mask ventilation. Lung isolation was achieved by using a 4.5 mm ID uncuffed oral endotracheal tube (ETT) which was made endobronchial and the position was confirmed by both auscultation and lung ultrasound. Right lateral position was maintained for the surgery. VATS was converted to open thoracotomy and decortication was done. Postoperatively, thoracic epidural (TE, 19G with 22G catheter) was placed at the T7 level and continuous epidural infusion (0.1% ropivacaine with 1 μg/ml fentanyl) was started at the rate of 0.3 mg/kg/h.

Case 2

A 1-year-old male child weighing 4 kg was admitted with fever, decreased appetite, and tachypnea (respiratory rate of 38/min). Clinical picture was suggestive of empyema on the right side, which was confirmed by CECT chest showing collapsed lung with loculations. VATS procedure was planned in the left lateral position. GA was administered with co-induction under the parental presence as described above. Lung isolation was achieved by Fogarty embolectomy catheter (3 Fr) passed parallel to the ETT (4.0 mm, uncuffed) and placed under guidance of pediatric fiberoptic bronchoscope to the left bronchus with confirmation done by auscultation. VATS procedure was done successfully. A local infiltration of the port site was done for pain relief.

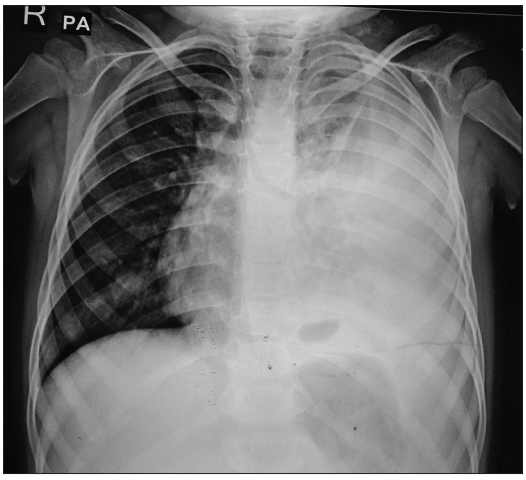

Figure 1: X-ray chest posteroanterior view showing homogenous opacity involving the entire left hemithorax with sparing of the upper zone of the left lung with large pleural effusion and mediastinal displacement

Case 3

A 1½-year-old male child weighing 4.5 kg was admitted with fever, cough, and night sweats with pain in the chest wall (left side). Clinical and radiological picture confirmed presence of empyema on the left side. VATS procedure was performed under GA after obtaining an informed consent. One-lung ventilation (OLV) was achieved with a 4.0 mm ID uncuffed ETT made endobronchial to the right side and was confirmed with auscultation. Postoperative pain management was done with multimodal analgesia including intercostal nerve block at the end of the surgery and IV paracetamol.

Case 4

A 3-year-old female patient presented with the unrelenting high-grade pyrexia, left-sided chest pain, and cough with tachypnea. Left sided empyema was diagnosed and VATS procedure was planned. Anesthesia was administered as per the institutional protocol. Left lung isolation was achieved under vision of the pediatric fiberoptic bronchoscope with 3 Fr Fogarty embolectomy catheter placed parallel to the 4.0 mm ID uncuffed ETT. Continuous epidural infusion through 22G epidural catheter secured at T7 level was used for postoperative analgesia.

Pain assessment tool

The pain assessment in the postoperative period in all the cases was done at 6 and 12 h, respectively, using a validated Face, Leg, Activity, Cry, Consolability (FLACC) score. The score is rated from 0 to 2 for each component. The score interpretation of 0 denotes comfortable and relaxed, 1–3 as mild discomfort, 4–6 indicates moderate pain, and 7–10 represents severe pain.[4]

The summary of all the cases is presented in Table 1.

Discussion

In an era of early recovery after surgery, its protocol thrusts upon minimally invasive surgical procedures such as VATS for the management of empyema thoracis. VATS uses 3–5 ports in the chest wall through small incisions which allow

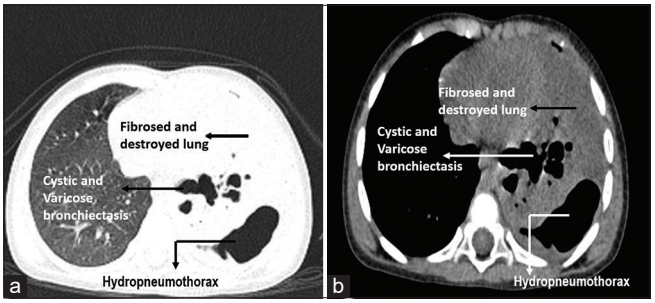

Figure 2: Noncontrast computed tomography thorax. (a) The lung window. (b) The mediastinal window. Each image showing hydropneumothorax, cystic and varicose bronchiectasis, and fibrosed and destroyed lung as marked with arrows

Table 1: Summary of the clinical cases

Description	Case 1	Case 2	Case 3	Case 4
Age (years)	4.5	1	1.5	3
Sex (male/female)	Female	Male	Male	Female
Weight (kg)	15	4	4.5	11
Stage of the disease	Stage 3	Stage 2	Stage 2	Stage 3
Operation technique	VATS converted to open thoracotomy	VATS	VATS	VATS converted to open thoracotomy
Lung isolation technique	Endotracheal tube made endobronchial	Endotracheal tube with Fogarty embolectomy catheter as bronchial blocker	Endotracheal tube made endobronchial	Endotracheal tube with Fogarty embolectomy catheter as bronchial blocker
Postoperative pain management	Paracetamol and thoracic epidural	Paracetamol and local infiltration	Paracetamol and intercostal nerve block	Paracetamol and thoracic epidural
FLACC score at 6 h	2	0	0	1
FLACC score at 12 h	3	2	1	3

VATS: Video-assisted thoracoscopic surgery

the introduction of a video camera and surgical instruments in the thoracic cavity. Growing familiarity with the procedure offers many advantages over traditional decortications, such as lesser opioid requirement, earlier achievement of preoperative activity levels, reduced risk of atelectasis with reduction in retained secretions, and reduced shoulder dysfunction.[5]

Diverse practices of management exist for the organized stage of empyema. The decision is based on the duration of presentation (>4 weeks), clinical deterioration and extent of the involvement of lung, as well as surrounding structures as delineated by CECT. Ability of VATS in assessing and stratifying the stage of the disease helps surgeons to go ahead with stripping and adhesiolysis through the dissecting plane between the lung and overlying peel or to proceed further with thoracotomy in cases of lung encasement with adherent organized fibrinous peel as was observed in our first and the fourth case. The conversion rate of VATS to thoracotomy therefore varies between 4.5% and 60% in various studies.[6,7] In our limited series, VATS was done initially but later converted to open thoracotomy in two cases due to per operative findings. VATS procedures are performed under OLV in the lateral decubitus position for a better exposure with the nondependent collapsed lung.

OLV is generally well tolerated in children in the absence of any pulmonary and cardiovascular disease. Ventilation (V) as well as perfusion (Q) is favored in the dependent lung in older children as in adults; this is attributed both to the gravitational pull and the pressure gradient. However, during VATS, V/Q mismatch can occur due to reduced functional residual capacity, retraction of lung, and its collapse following lung isolation during ventilation.[8,9] Hypoxic pulmonary vasoconstriction compensates by diverting the perfusion from the atelectatic lung to the ventilated-dependent lung. This response gets affected at the extremes of partial pressure of venous oxygen, by inhalational agents as well as with vasodilators.[8]

Infants differ in their physiologic response toward lateral decubitus position. Their compressible chest wall is unable to support the dependent lung and further increase its propensity toward atelectasis due to reduced compliance and airway closure during normal respiration.[8,9] Due to their smaller size, the gradient of hydrostatic pressure generated between the two lungs mitigates completely the advantageous position of the dependent lung in terms of perfusion. Consequence to this, there are increased chances of intraoperative hypoxia which can be dealt by oxygenating and ventilating the nondependent lung. Marraro's bi-lumen, parallel ETT with shorter length end for the trachea and longer end tube for the bronchus is intended for this use up to 3 years of age.[10] Hale *et al*. studied impact of the lung isolation in pediatrics on pulmonary mechanics and observed that the prolonged OLV affects the compliance of the lungs, otherwise normally the pre-OLV compliance, PaO_2/FiO_2 ratio, and $P(A\text{-}a)O_2$ gradient correlated well with the post-OLV values with only significant change during OLV.[11]

Options for lung isolation in pediatrics are varied depending on the size of the airways, its availability, and the expertise of the anesthesiologist. Single-lumen ETT with deliberate endobronchial intubation of the side to be ventilated is most commonly employed clinically; it causes gradual absorptive atelectasis of the pathologic lung and is recommended for the age less than 6 months but can be used up to 18 years.[12] In our case series, we have used endobronchial ETT in two cases [Table 1]. It has the disadvantage of incomplete collapse and inability to suction the operative lung. Cohen *et al*. have found fluoroscopy as an effective way to ascertain the correct positioning of ETT in isolation during endobronchial intubation and with bronchial blockers in infants, when compared to fiberoptic bronchoscopy.[13] Bronchial blockers are commonly used beyond 6 months up to 8 years. It includes Fogarty catheter (3 Fr and 5 Fr) which was successfully used in our two cases, has a high-pressure balloon when inflated for lung isolation; uniblocker (5 Fr), EZ blockers, and Arndt endobronchial blocker (5 Fr) are the others in this category.[10,12] The advantage of Arndt bronchial blocker is that it has a working channel which can aid in suction of the operative lung as well as can provide CPAP.[10,12] Bronchial blockers can

be placed coaxially or parallel to the ETT using the fiberoptic bronchoscope and can get displaced easily causing the airway obstruction. Univent tube (3.5 mm ID, 4.5 mm ID) has separate lumen for the blocker, with only one disadvantage of increase airway resistance due to the decreased cross-sectional area.[10,12] Double-lumen tube (26 Fr) is the one suitable beyond 8 years of age, with a height of 130 cm and a weight of at least 30 kg. Confirmation of the lung isolation can be done by auscultation of the chest which in pediatrics can have false-positive results; therefore, with lung ultrasound, one can conveniently confirm it with the absence of "lung sliding sign" for the nonventilated lungs or with "lung pulse sign" where the pleural lines synchronize with the heart beat, indicating lung collapse, having sensitivity of 93%.[10]

Postthoracotomy pain is a debilitating condition and is seen in 50% of the patients; the pathogenesis include both neuropathic and myofascial pain. VATS being minimally invasive does not involve muscle cutting and splaying of ribs for exposure as with thoracotomies; therefore, it is thought to be associated with lesser postoperative pain. However, literature shows that it is a misnomer, as stripping of the well-innervated parietal pleura from the visceral pleura in the presence of background inflammation and insertion of the intercostal tube drain invokes good amount of pain, despite attempting thoracoscopic procedure.[14] Multimodal approach toward postoperative pain is a key in decreasing the postoperative pulmonary complications. No uniform guidelines exist, but in majority, Nonsteroidal anti-inflammatory drugs (NSAIDs) and paracetamol are combined with regional techniques such as TE, paravertebral blocks (PVBs), interpleural analgesia, serratus anterior plane block (SAPB), local infiltration of the incision site, or erector spinae bocks, with each technique having its advantages and disadvantages. Patient-controlled analgesia with opioids in pediatrics is debatable with increased chances of respiratory depression.[9,14,15] In our series, paracetamol was combined with the regional technique, TE in two cases, intercostal nerve block in one case, and local infiltration in the remaining one. FLACC score never exceeded 2 in all cases at 6 h and never more than 3 at 12 h. Karnik *et al*. have reiterated the efficacy of epidural analgesia in reducing pain in pediatric patients undergoing VATS for decortication following empyema when compared with the local infiltration along with systemic opioids.[14] Mercieri *et al*. in their review found that PVB is superior to TE as a modality for pain relief but considered TE as a gold standard when there were concerns of conversion to open thoracotomy.[15] New blocks, SAPB and erector spinae plane block seems promising in terms of efficacy and reproducibility.[14,16]

To conclude, VATS is an acceptable way of treating empyema in pediatric age group, which poses a great deal of challenge to both surgeons and anesthesiologist. Better outcomes are subject to achieving single-lung ventilation, preventing hypoxia during the procedure, achieving complete lung expansion postprocedure, and providing adequate postoperative analgesia for speedy recovery.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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