Chapter

23 Thoracic Surgery in Children

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Case 1: A six-year-old with a history of osteosarcoma postchemotherapy and resection 18 months prior, presents with a new cough, shortness of breath and expiratory wheezing. The workup reveals a new mass in the right middle lobe as well as a large pleural effusion. Following CT-guided biopsy confirming metastatic disease, the surgeons plan to resect the mass via video-assisted thoracoscopic surgery (VATS).

What Is the Most Likely Cause of This Lung Mass?

Primary lung tumors are uncommon in children, with benign lung lesions being 10 times more common than malignant ones.

Secondary lung tumors are unfortunately more common with metastatic tumors comprising 80% of all lung tumors, of which 95% are malignant. In this patient, despite previous treatment, the most likely scenario of a new lung mass is recurrence of osteosarcoma with lung metastases.

In a child with no history of malignancy, the workup for new solitary lung tumors is quite different. Recommendations are to treat per symptoms, obtaining a baseline chest X-ray and labs. If symptoms persist beyond two to four weeks, a chest CT is warranted as is pulmonology consultation. If the chest CT is negative, treatment is continued for another two to four weeks prior to repeating a chest CT and bronchoscopy. If the CT reveals a lung mass, biopsy is warranted. Peripheral lung lesions are often amenable to open surgical biopsy or percutaneous biopsy in interventional radiology. Central lesions are biopsied via a bronchoscopic approach.

What Are the Differences Between VATS and Open Thoracotomy?

Video-assisted thoracoscopic surgery (VATS) was first performed in children in the mid-1970s. The contraindications to VATS include: (1) empyema with development of fibrosis obliterating obvious space between the ribs and (2) densely adherent tumor infiltrating the chest wall. The advantages of VATS over conventional thoracotomy include:

1. A reduction in postoperative pain from rib retraction during thoracotomy which occurs even if muscle sparing incisions are performed.
2. Reduction in musculoskeletal sequelae, as conventional thoracotomy leads to asymmetry of the thoracic wall from atrophy of the chest muscles as well as the development of ipsilateral scoliosis.
3. Improved recovery, with shorter hospitalizations and faster return to normal activities of daily life.

What Are the Preoperative Considerations Prior to Lung Tumor Resection?

Preoperative evaluation typically includes routine labs, chest X-ray, and CT scan of the chest. Preoperative echocardiography is necessary in settings where external cardiac compression is considered. Type- and cross-matched blood should be available. Despite plans for a thoracoscopic approach, conversion to open thoracotomy with potential for significant blood loss always remains a possibility.

What Are the Options for Lung Isolation?

The primary need for any endoscopic procedure is adequate visualization and space to work. This is achieved by collapsing the operative lung. Lung isolation in small children may prove difficult.

1. Double Lumen Tube (DLT)

   This device fuses two tubes of unequal length, with one terminating in the trachea and the other in a bronchus (right or left) allowing for ventilation of one or both

https://doi.org/10.1017/9781108668736.024 Published online by Cambridge University Press

lungs. The DLT also helps minimize the risk of contralateral lung contamination and allows for suction and maintenance of positive pressure as needed to either lung. Its limitation is size as the smallest DLT is a 26Fr, acceptable for ages 8–10, with an outer dimeter of 8.7 mm, comparable to a 6.5 mm internal diameter endotracheal tube, preventing its general use in younger pediatric patients.

2. Bronchial Blocker

   A balloon catheter is positioned in the proximal mainstem bronchus under fiberoptic visualization. If no true bronchial blocker is available, a Fogarty Occlusion Catheter or balloon wedge pressure catheter may be substituted. Inflation of the balloon blocks ventilation to the distal lobes or entire lung. Disadvantages include difficult placement in small children and frequent dislodgement. In situations where the balloon migrates into the trachea, full ventilatory obstruction may occur. Other issues include potential over-distension of the balloon with resultant tissue damage of the airway, inability to suction the operative lung, and an inability to apply continuous positive airway pressure to the operative lung. A bronchial blocker is often used in young children <8 years.

3. Univent Tube

   This is a tracheal tube with a bronchial blocker within a separate lumen, allowing advancement with inflation or withdrawal and deflation should double-lung ventilation be required. These tubes are available for pediatric sizes in 3.5 and 4.5 mm ID, allowing the youngest age of use to be approximately 6 years. This provides an optimal option between ages six and eight, at which point a double lumen tube is the preferred option.

4. Standard Single Lumen Endotracheal Tube with Intentional Mainstem Bronchus Intubation

   This is the preferred method for children ages zero to six months, but can be acceptable up to 18 years. A fiberoptic bronchoscope may be passed to confirm placement. Disadvantages include failure to provide an adequate seal, an inability to suction the operative lung, and hypoxemia due to obstruction of the right upper lobe bronchus. The inability to quickly change from one lung ventilation to two lung ventilation is the major drawback of this technique for occlusion of the operative lung.

5. Capnothorax

   In young infants, carbon dioxide insufflation into the operative hemithorax produces lung collapse. It provides adequate surgical visualization but may lead to hemodynamic effects that may not be well tolerated for long periods of time. To ameliorate these effects, low pressure insufflation is necessary, with discontinuation of insufflation should hemodynamic changes occur. Additional considerations for the anesthesiologist include hypothermia caused by a large volume of cold CO_2 in the thoracic cavity and prolonged hypercapnia in the setting of longer procedures.

Both the bronchial blocker and mainstem intubation methods of lung isolation rely on obstruction of the nonventilated bronchus for lung collapse via "absorption atelectasis." This leads to relatively slow lung deflation and reinflation. Verification of appropriate position of any device is necessary following changes in position of the patient.

How Do You Treat Resultant Hypoxemia Associated with One-Lung Ventilation?

1. If severe, switch to two-lung ventilation immediately.
2. Check position of the occluding device with fiberoptic bronchoscopy.
3. If possible, apply continuous positive airway pressure (CPAP) to the nondependent lung.
4. Apply positive end expiratory pressure (PEEP) to the dependent lung.
5. Intermittently ventilate both lungs.
6. In an emergency, the surgeon can clamp the ipsilateral pulmonary artery reducing ventilation: perfusion mismatch.

What Are the Options for Postoperative Pain Control?

Optimal analgesia is provided via a combination of regional anesthesia, opioids, and other adjuncts. Thoracic epidural blockade is achieved via placement of the epidural catheter inserted directly between T4 and T8 (depending on the level of the thoracotomy) and can be used to provide intraoperative and postoperative analgesia. Placement of a thoracic epidural catheter can safely be performed by experienced practitioners in neonates, with extremely low complication rates. Some providers prefer to approach the thoracic space using a caudally threaded epidural catheter. In this case, the caudal space is accessed and a wire reinforced catheter is advanced to the

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appropriate thoracic level. Often, fluoroscopy is used to confirm the epidural tip location.

Options for local anesthetics in the epidural space include bupivacaine, chloroprocaine, and ropivacaine. Adjunct agents most commonly selected are clonidine, fentanyl, or hydromorphone. Intravenous analgesia can be obtained with continuous infusions of opioid.

Intracostal nerve blocks, thoracic paravertebral blocks, or intrapleural installation of local anesthetic also aids in providing pain relief from chest tubes or incisions. Newer options such as erector spinae plane blocks and catheters have been successfully replacing thoracic epidurals. This technique affords a substantially improved safety profile, especially in small neonates.

Case 2: A five-day-old, 3.3 kg full term neonate, with no prenatal care, presents with increasing respiratory distress, tachypnea with room air oxygen saturation of 93%. Chest X-ray shows hyperinflation of the left lung; CT scan shows emphysematous hyperinflation of the left upper lobe. A diagnosis of congenital lobar emphysema is made.

What Are the Major Congenital Lung Malformations?

1. Congenital lobar emphysema (CLE) or Congenital Lobar Overinflation (CLO)

   Progressive lobar expansion leads to compression of the ipsilateral lung, due to either extrinsic airway compression or intrinsic cartilage abnormalities, leading to air trapping. This typically involves only one lobe, and is often diagnosed on prenatal ultrasound. Symptoms vary, with less severe CLE not presenting until the child is older. Approximately 10–15% of patients with CLE have associated cardiovascular anomalies. Neonates in severe distress or those with progressive decompensation will require emergent thoracotomy and resection, while elective surgery may be an option for the older child with moderate symptoms in no distress. Asymptomatic patients with small lesions may not need surgery.

2. Congenital Pulmonary Airway Malformation (CPAM) and Congenital Cystic Adenomatous Malformation (CCAM)

   This group of cystic and non-cystic lesions result from abnormalities in early airway development (Figure 23.1). They are often recognized on prenatal ultrasounds or discovered due to respiratory difficulties or recurrent infections. CPAMs are classified based on cyst size and histologic features. Symptomatic infants are treated with lobectomy or segmental resection.

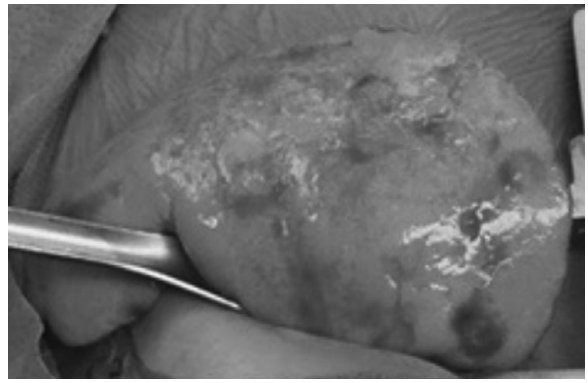

Figure 23.1 Intraoperative specimen of lung demonstrating numerous cystic malformations.

3. Bronchopulmonary Sequestration

   This developmental lung lesion involves a portion of the lung that is independent of the tracheobronchial tree and has a separate systemic arterial supply, usually from the thoracic or abdominal aorta. The extra-lobar form has its own pleura and venous drainage, while the intra-lobar form shares pleura with the normal lung and drains into the pulmonary venous system. Extra-lobar lesions are usually diagnosed via prenatal ultrasound, while intra-lobar sequestration is often diagnosed in childhood or adulthood, often identified during a workup for recurrent lower lobe pneumonia. Symptomatic infants need urgent resection of the lesion. Asymptomatic patients undergo surgical resection in an elective fashion.

What Are the Management Strategies in a Symptomatic Neonate with a Congenital Lung Mass?

1. Preserve spontaneous respirations.
   a. Escalate noninvasive respiratory support as needed (blow-by oxygen, CPAP, bi-level positive airway pressure (BiPAP).
2. Intubate if in respiratory distress.
3. Ventilation after intubation.
   a. Spontaneous vs. controlled vs. high frequency oscillatory ventilation.

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b. Positive pressure ventilation may lead to rapid inflation of the cystic lesion, with subsequent mediastinal shift and cardiopulmonary decompensation. Emergency decompression of hyperinflated cyst may be necessary from positive pressure ventilation.
c. High frequency oscillatory ventilation (HFOV) maybe indicated to keep constant pressures and avoid barotrauma.

4. Emergency surgery may be needed in settings of severe respiratory compromise.

Suggested Reading

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