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Surgical management for complications of pediatric lung injury

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ABSTRACT

The etiologies of pediatric lung injury requiring surgical intervention can be infectious, traumatic, congenital, or iatrogenic. Childhood pneumonia is a significant global health problem affecting 150 million children worldwide. Sequelae of pulmonary infections potentially requiring surgery include bronchiectasis, lung abscess, pneumatocele, and empyema. Trauma, congenital conditions such as cystic fibrosis and iatrogenic injuries can result in pneumothoraces, chylothoraces, or bronchopleural fistulae. Recurrence rates for spontaneous pneumothorax treated non-operatively in pediatric patients approach 50–60%. Chylothoraces in newborns may occur spontaneously or due to birth trauma, whereas in older children the etiology is almost always iatrogenic. This article examines the surgical management for the complications of lung injury in pediatric patients. In addition, we review the available pediatric evidence for early tracheostomy as well as treatment strategies for the negative ramifications of tracheostomy.

Introduction

Lung injuries requiring surgical intervention in the pediatric critical care patient can be complicated to treat and, consequently, require timely diagnosis and referral to a pediatric surgeon. The etiologies of these conditions can vary and include infection, trauma, congenital, and iatrogenic causes. Bacterial pneumonia occurs at an estimated rate of 30–40 per 100,000 children in the United States and Europe[1] and affects 150 million children worldwide annually.[2] Pneumonia may progress to parapneumonic effusions in up to 53% of cases[3] and can ultimately lead to bronchiectasis, pulmonary abscess, pneumatocele, or empyema; conditions that often require operative treatment. Trauma, congenital abnormalities, and iatrogenic injuries can result in recurrent pneumothoraces, chylothoraces, or bronchopleural fistulae. We aim to review surgical management for the complications of lung injury in pediatric patients in the critical care setting. In addition, there appears to be a paucity of data to recommend optimal duration of endotracheal intubation in children requiring mechanical ventilation. We attempt to answer this question by suggesting timing of tracheostomy and, additionally, offer management strategies for tracheostomy-related complications in the pediatric intensive care unit (PICU).

Bronchiectasis

Initially described in 1819, bronchiectasis is the abnormal, irreversible dilatation of bronchi due to destruction of elastic tissues and muscles of the bronchial wall.[4] Though the incidence has declined considerably with the advent of effective antibiotics, bronchiectasis continues to be encountered in pediatric patients, primarily those with cystic fibrosis or severe pulmonary infection, which is the major etiology overall.[4] Symptoms include cough, profuse sputum, wheezing, chest pain, and clubbing, which nearly half of patients may exhibit. Bronchography or use of contrast-enhanced radiographs have largely been replaced by high-resolution computed tomography (CT) (Figure 1) to confirm diagnosis.[5]

Prevention of bronchiectasis initially targets management of the underlying cause. For example, antibiotics, microbiologic surveillance, nutritional support, appropriate vaccination, postural drainage, mucolytics, and chest physiotherapy have shown some benefit preventing bronchiectasis when implemented in cystic fibrosis patients.[6–8] With conservative management strategies, mortality rates for bronchiectasis patients have been reported as high as 19–31% in developing countries.[9] Outcomes are better in industrialized nations for conservative management, but surgical resection is the only treatment modality that can offer a permanent cure.[9]

Definitive indications for surgery in pediatric patients with bronchiectasis have not been established. In adults, resistance to antibiotics, postural drainage, and physical therapy for greater than 2 years have been described as reasons for surgical excision of diseased lung.[10] While these indications are applicable to children, pediatric patients with poor quality of life due to severe cough,

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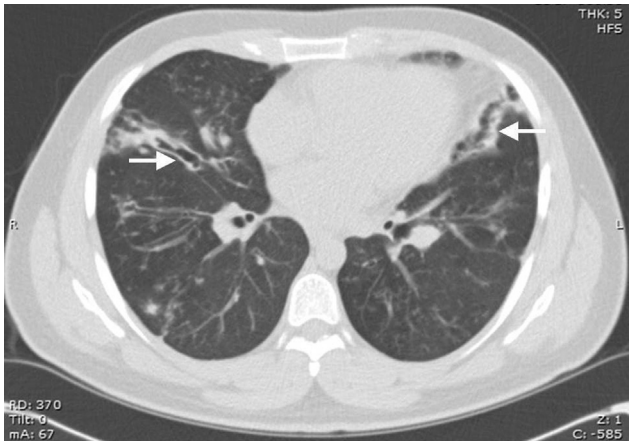

Fig. 1. Computed tomography of the chest from an adolescent with cystic fibrosis showing prominent bilateral bronchiectasis (arrows), peribronchial cuffing, and infiltrates.

life-threatening hemorrhage, failure to thrive/growth retardation, or decrease in school attendance secondary to bronchiectasis should also be considered for surgery. To date, retrospective studies suggest complete symptom resolution in 42–73% of children who undergo surgical resection of the bronchiectatic portion of lung.[10–12] Symptom recurrence primarily is due to incomplete resection. Reported mortality rates for surgical resection are as high as 5.6%. Postoperative complications including atelectasis, prolonged air leak, empyema, and hemorrhage occur in 13–17% of patients. Although open lobectomy traditionally has been the standard for resection, an expanding body of literature supports thoracoscopic resection of bronchiectatic lung segments. Thoracoscopic resection can be accomplished safely in selected children with outcomes comparable to open thoracotomy.[13]

Pulmonary abscess

Lung abscess develops when localized pneumonia progresses to necrosis and cavitation of lung parenchyma. Although lung abscesses are a rare entity in children, with an estimated incidence of 0.7 per 100,000,[14] they often require surgical treatment. Pneumonia is almost always the precursor disease, but in infants and young children an underlying aspirated foreign body or congenital lung abnormality should be considered. Symptoms include fever, cough, chest pain, anorexia, productive sputum, malaise, hemoptysis, or chills. Diagnosis can be made with a chest radiograph (Figure 2) showing a cavity with an air–fluid level; however, the radiographic appearance of an abscess may be indistinguishable from empyema with an air–fluid level. CT scan of the chest provides more detailed information regarding location, size, and relation to other pulmonary structures.

Treatment should begin with intravenous antibiotics tailored to the causative organism, typically administered for 2–3 weeks, accompanied by postural drainage and physiotherapy.[14] Sputum for microbial analysis should be obtained to guide therapy. Younger children who are not able to cough adequately to produce sputum may require bronchoscopy with sputum sampling. *Staphylococcus* or *streptococcus* species are typically the causative organisms; however, Gram-negative and anaerobic species should be suspected in patients with aspiration.

Percutaneous drainage has largely replaced surgical drainage due to advancements in radiology-guided techniques. Typically, such procedures are utilized in children who are severely ill or do not respond to medical treatment within 7–10 days. Complications of percutaneous drainage include pneumothorax, hemothorax,

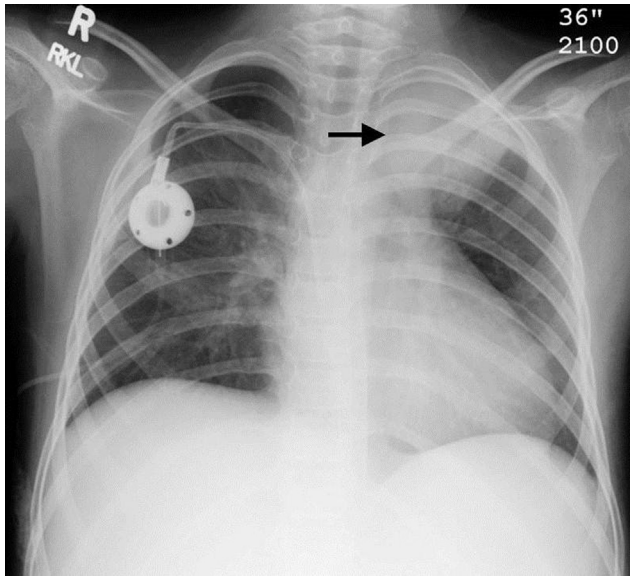

Fig. 2. Chest radiograph of a child with a history of bone marrow transplant showing upper lobe pulmonary abscess (arrow). Note central lucency indicating area of cavitation.

incomplete drainage, and bronchopleural fistula.[15,16] Very little data has been published describing the outcomes of percutaneous drainage in children, and no randomized controlled trials have been reported. However, a recent review of published series dating back to 1975, including 105 adult and pediatric cases, indicates percutaneous drainage may be successful in 85% of patients with a complication rate of 10% and mortality of 5%.[16] Procedure failure has been associated with a thick-walled or poorly defined abscess or presence of multiple loculations within the abscess cavity. All of the reported mortality occurred in a single series of 8 patients (5 of 8 died) with poor prognostic indicators including secondary abscesses, comorbidity, and virulent pathogens.

Surgical drainage of lung abscess by segmental resection or lobectomy has been described since the 17th century and is reserved for chronic, large, thick-walled abscesses or for the few patients who do not respond to intensive antibiotic therapy and percutaneous drainage.[17] Other indications include chronic abscesses lasting greater than 3 months, bronchial stenosis, bronchiectasis, pulmonary necrosis, and persistent hemoptysis causing anemia. In immunocompromised children, who may be susceptible to failure of medical therapy and drainage, more extensive pulmonary resection may be preferable to limited resection to adequately eradicate the abscess and prevent recurrent infection. Despite the inherent higher surgical risk of extensive resection in these patients, morbidity and mortality for this aggressive approach are comparable to that achieved in immunocompetent patients undergoing less extensive resection.[18] Successful thoracoscopic drainage of pulmonary abscess has been described[19]; however, comparisons of efficacy between percutaneous and thoracoscopic drainage techniques are lacking.

Pneumatocele

Pneumatoceles are thin-walled structures with single or multiple air-filled cysts, which form due to bronchoalveolar necrosis. Generally, the necrosis is a result of a staphylococcal infection but may be due to *Streptococcus*, *Haemophilus*, *Pseudomonas*, *Mycobacterium*, *Serratia*, *Klebsiella*, *Escherichia coli*, trauma, or hydrocarbon-induced pneumonia.[20] Radiologic evidence most often occurs on the fifth to sixth day of hospitalization (Figure 3).[20] Pneumatoceles