

Etiology and Management of Pediatric Hemoptysis

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Objective: To review the diagnostic and treatment strategies of hemoptysis in children.

Design: Retrospective analysis of patients evaluated between January 1, 1995, and August 31, 1999.

Setting: Tertiary pediatric referral center.

Patients: Nineteen consecutive children presenting with hemoptysis to the otolaryngology service.

Results: Chest radiography and bronchoscopy established the correct etiology in 15 patients. Infection and tracheostomy-related complications were the most common underlying problems. Other causes included congenital heart disease, pulmonary hemosiderosis, inflammatory bronchial mass, cystic fibrosis, factitious

hemoptysis, and esophagitis. Appropriate management, ranging from antibiotics to emergency embolization, resulted in control of hemoptysis in all patients.

Conclusions: Hemoptysis is a rare but potentially life-threatening symptom of underlying respiratory tract abnormality in children. An efficient systematic evaluation is imperative to identifying the underlying etiology; aggressive management is important because of the potential severity of the problem. The otolaryngologist plays a pivotal role in the diagnosis and management, by flexible endoscopy of the nose, nasopharynx, and larynx, and through the use of rigid bronchoscopy, especially in cases of massive hemoptysis.

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HEMOPTYSIS is defined as the expectoration of blood or blood-tinged sputum.¹ Although common in adults, blood-tinged sputum is a rare presenting symptom in children. The diagnosis of pediatric hemoptysis can be challenging. Children tend to swallow their sputum; therefore, hemoptysis may go unnoticed unless the bleeding is substantial.² Inability to provide a complete history and to cooperate with a thorough physical examination may further compound the diagnostic dilemma. Thus, hemoptysis can serve as a source of significant anxiety for the patient, the family, and the pediatrician.

Most important is to first establish that the child is indeed experiencing hemoptysis. Extrapulmonary bleeding, such as from the nose or the gastrointestinal tract, may be incorrectly attributed to hemoptysis. Hematemesis can be confused with hemoptysis, especially in children. Because the diagnostic and treatment strategies differ markedly, the 2 sources must be differentiated. The blood in hemoptysis is generally bright red or rust and may

be admixed with sputum and frothy. The blood in hematemesis is dark red or brown and may be mixed with food particles. The bleeding in hematemesis is commonly preceded by vomiting or retching. The pH of hemoptysis is generally alkaline, while the pH of hematemesis is acidic.³ Once the distinction is made, the physician can proceed to discovering the underlying cause.

Although tuberculosis was once the primary underlying cause of hemoptysis, today the etiologies are multiple and diverse.⁴ The etiology in children generally differs from that in adults. Hemoptysis in adults is most often caused by bronchitis, bronchogenic carcinoma, tuberculosis, or bronchiectasis.^{5,6} On the other hand, pediatric hemoptysis is most likely to be secondary to infection, tracheostomy-related problems, or foreign body aspiration.^{1,7,8} Most cases are mild and self-limited. However, the potentially life-threatening lesions related to pulmonary vascular anomalies and congenital heart disease (CHD) must be identified. Estimation of the volume of blood lost (life-threatening threshold, >8 mL/kg every 24 hours) is useful for clinical assessment in these patients. Thus,

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PATIENTS AND METHODS

A retrospective medical chart review was conducted to identify all children presenting with hemoptysis to the otolaryngology service at Children's Memorial Hospital, Chicago, Ill, between January 1, 1995, and August 31, 1999. Twenty children were evaluated for 22 episodes of hemoptysis during this period, with 1 patient being evaluated on 3 separate occasions. One patient was excluded from the final analysis because the recommended workup was not completed. The remaining 19 medical charts were carefully examined to determine the following: demographic data, associated symptoms, quantity of hemoptysis, comorbid conditions, laboratory studies, sputum cultures, and radiologic workup, including chest radiography, computed tomography, and arteriography. The operative records were reviewed for the findings at bronchoscopy or esophagoscopy, when performed as part of the diagnostic workup. The etiology, treatment, and clinical course were also noted from the patients' medical records.

a rapid, systematic evaluation is conducted in all children to discover the cause of hemoptysis.

The otolaryngologist consulted to assist in the evaluation of pediatric hemoptysis is in a unique position to evaluate endoscopically the upper and lower respiratory tracts for the site of bleeding. Rigid bronchoscopy is an important tool for establishing the site of bleeding and for securing an airway in cases of massive hemorrhage. It is therefore critical to understand the various etiologies, diagnostic modalities, and treatment strategies available for management of hemoptysis in children.

RESULTS

The 19 children ranged in age from 7 weeks to 18 years (mean age, 5.2 years). The male to female ratio was almost 3:1, with 14 males and 5 females. Hemoptysis was the sole presenting symptom in 13 patients. Five patients had concomitant fevers, while 3 also had cough. In 1 child, the possibility of hematemesia as the source of bleeding could not be ruled out. The quantity of hemoptysis was not specified in 12 patients. One child presented with significant bleeding of more than 200 mL. The remaining 6 patients presented with mild to moderate hemoptysis, ranging from 20 to 100 mL.

These 19 patients had multiple associated conditions. Six were tracheostomy-dependent; 1 had undergone laryngotracheal separation for aspiration due to severe neurologic compromise. Six children had CHD, including tetralogy of Fallot (2 patients), coarctation of the aorta (2 patients), ventricular septal defect (2 patients), atrial septal defect (2 patients), transposition of great vessels (1 patient), and arteriovenous canal (1 patient). Other comorbid conditions included subglottic stenosis (2 patients), seizure disorder (2 patients), bronchopulmonary dysplasia (2 patients), progressive my-

opathy (1 patient), agenesis of the corpus callosum (1 patient), Robin sequence (1 patient), cystic fibrosis (1 patient), tracheoesophageal fistula (1 patient), and Möbius syndrome (1 patient).

The laboratory workup included a complete blood count with platelets in all patients. Anemia requiring transfusion was identified in 3 patients. A coagulopathy workup, including prothrombin time and partial thromboplastin or bleeding time (or both), was performed on 7 patients. All of these workups showed no abnormalities. Sputum was collected from 9 patients, most commonly during bronchoscopy. Four cultures were positive for the following organisms: *Pseudomonas*, *Pseudomonas/Serratia/Klebsiella*, methicillin-resistant *Staphylococcus aureus*, and *Candida albicans*. Five cultures were negative for bacterial, fungal, and mycobacterial organisms. Bronchoalveolar lavage was performed in 2 patients; the presence of hemosiderin-laden macrophages helped confirm the diagnosis of pulmonary hemosiderosis (PH) in both cases.

Fifteen (79%) of 19 children underwent preoperative chest radiography. Seven films (47%) were normal; 8 others showed evidence of infiltrates. Focal infiltrates were demonstrated in all 3 patients with pneumonia. Bilateral patchy to interstitial infiltrates were seen in patients with PH and CHD. One chest radiograph showed a subtle density next to the right hilum. Three of 19 children underwent chest computed tomography. Two had normal findings, while 1 patient demonstrated left lower lobe undifferentiated bronchiectasis vs emphysema. Three angiograms were performed on 2 patients with CHD. Angiography demonstrated aberrant bronchial collateral circulation in both cases. The collaterals were embolized with absorbable gelatin sponge in 1 patient and with coil and polyvinyl alcohol particles in the other patient on 2 occasions.

Twenty-four bronchoscopies were performed in 18 (95%) of the 19 patients. One child with aberrant bronchial circulation underwent bronchoscopy on 3 occasions for diagnostic and therapeutic reasons. Four children had follow-up bronchoscopy. Eighteen procedures (75%) were performed in the operating room, 6 (25%) at the bedside in the intensive care unit or in the emergency department. Eleven of 18 patients had findings at initial bronchoscopy that were helpful in arriving at the correct diagnosis. These findings at bronchoscopy are listed in **Table 1**. Blood in the tracheobronchial tree was the most common finding. Blood clots were noted during 5 procedures, active bleeding in 2 others. Purulence and mucosal inflammation were noted in 4 patients each. Other abnormalities included tracheal abrasions (2 patients), granulation tissue (1 patient), and an inflammatory bronchial mass (1 patient). Esophagoscopy was performed in 2 patients. The patient suspected of hematemesia had erosive esophagitis. The other esophagram showed no abnormalities.

Using the findings of bronchoscopy and radiographic studies, the correct etiology was determined in 17 (81%) of 21 episodes of hemoptysis. In 4 (21%) episodes of hemoptysis, no cause of bleeding was identified. The etiologies for hemoptysis are listed in **Table 2**. Infection was the most common, with 3 cases each of

Table 1. Bronchoscopic Findings in 11 of 18 Patients

Finding	No. (%)*
Blood clots	7 (36.8)
Purulence	4 (21.0)
Mucosal inflammation	4 (21.0)
Tracheal abrasion	2 (10.5)
Granulation tissue	1 (5.3)
Bronchial mass	1 (5.3)

*Percentages do not sum to 100 because of rounding.

pneumonia and tracheobronchitis. Hemoptysis was tracheostomy-related in 3 cases. Aberrant bronchial circulation and idiopathic PH were diagnosed in 2 cases each. Others causes included inflammatory bronchial mass, factitious hemoptysis, cystic fibrosis, and esophagitis.

Treatment was commenced in 13 patients after establishing the underlying cause of hemoptysis. Antibiotics were used in 5 patients, resulting in resolution of all 3 cases of pneumonia and 1 case of tracheobronchitis. Use of antibiotics and corticosteroids resulted in improvement of the cystic fibrosis exacerbation in 1 patient. Tracheostomy care modification, including humidity, change in suction technique, and use of soft red-rubber catheters, helped resolve the bleeding in the 3 cases of tracheostomy-related hemoptysis. Oral corticosteroid use led to resolution of the hemoptysis in both cases of PH. Endoscopic removal of the inflammatory bronchial mass and subsequent application of topical oxymetazoline hydrochloride resulted in resolution of hemoptysis in that patient. Arterial embolization was performed 3 times in the 2 children with aberrant bronchial circulation, with resolution of the hemoptysis. The child with erosive esophagitis was treated with antireflux precautions and omeprazole.

With appropriate management, hemoptysis resolved in 18 (95%) of the 19 patients. One child with aberrant bronchial circulation had recurrence of bleeding following embolization during the same hospitalization; hemorrhage was controlled with a second embolization. Transfusion was necessary. Two other children with the diagnoses of PH and inflammatory bronchial mass also required blood transfusion for hemoglobin levels of 6.7 and 8.2 g/L, respectively. No deaths were attributed to the hemoptysis in this series.

COMMENT

ETIOLOGY

The 2 most common causes of hemoptysis in this patient population were infection (29%) and tracheostomy-related problems (14%). The etiology was not established in 4 children (21%), even after thorough evaluation in concordance with other studies of hemoptysis reported in the otolaryngology literature. Infections were the most common cause of hemoptysis in these series.^{1,7,9} Other common causes found in these studies included tracheostomy-related trauma and foreign body aspiration. No etiology was identified in 12% to 18% of the patients.

Table 2. Etiology of 21 Episodes of Pediatric Hemoptysis

Etiology	No. (%) of Episodes
Infection	6 (28.6)
Pneumonia	3 (14.3)
Tracheobronchitis	3 (14.3)
Unknown	4 (19.0)
Tracheostomy-related	3 (14.3)
Aberrant bronchial circulation	2 (9.5)
Pulmonary hemosiderosis	2 (9.5)
Bronchial mass	1 (4.8)
Factitious hemoptysis	1 (4.8)
Cystic fibrosis	1 (4.8)
Esophagitis	1 (4.8)

*Percentages do not sum to 100 because of rounding.

Acute lower respiratory tract infection, either pneumonia or tracheobronchitis, may account for up to 40% of the cases.³ The mechanism of hemoptysis in these cases is inflammation and friability of the tracheobronchial tree and the pulmonary parenchyma, with increased susceptibility to bleeding, which may be precipitated by forceful coughing. In these cases, bronchoscopy reveals erythema and edema of the tracheobronchial tree, mixed with purulent secretions, especially in patients with pneumonia. The respiratory mucosa is fragile and bleeds easily on contact with instrumentation. The pneumonic process may be bacterial, tuberculous, or fungal in origin. In this series, the microbial findings in the 3 cases of pneumonia included bacterial pathogens (*Pseudomonas*, *Pseudomonas/Serratia/Klebsiella*) in 2 patients and fungal (*C albicans*) in 1. Although tuberculosis used to be commonly implicated, few cases have been reported in the pediatric literature.^{1,9} No such cases were identified in our series.

Bleeding is a well-recognized complication of long-term tracheostomies. Wetmore et al¹⁰ reported that significant bleeding may occur in approximately 10% of the patients with long-term tracheostomy. Although bleeding in most of these cases is limited, any bright red bleeding should be promptly evaluated to rule out a tracheoinnominate artery fistula.¹¹ Fabian and Smitheringale⁷ found tracheostomy-related bleeding to be the second most common (occurring in 15.5% of cases) cause of hemoptysis, as it was in this series (3 [14%] of 21 cases). Typically, the bleeding was described as pink or red-tinged secretions noted on suctioning the tracheobronchial tree. All 3 patients underwent flexible bronchoscopy at bedside to evaluate the bleeding. Tracheal mucosal abrasions were noted in 2 patients; granulation tissue just proximal to the carina was found in 1. The bleeding was self-limited and resolved with humidification and use of soft red-rubber suction catheters in all 3 cases of catheter-related trauma.

Foreign body aspiration is always considered in the differential diagnosis of pediatric hemoptysis. The bleeding in this case results from mechanical trauma to the respiratory epithelium or the ensuing inflammatory reaction, especially to vegetable matter.¹² Tom et al¹ identified foreign bodies as the second most common cause of hemoptysis. Dore and associates¹² reported 2 cases of hemoptysis in otherwise healthy children due to an un-

suspected foreign body. Both eventually required lobectomy for removal of retained vegetable material and for definitive control of the bleeding. No such cases were identified in our series, although a low threshold of suspicion for foreign body aspiration is maintained at our institution. Any child with unexplained wheezing or paroxysmal coughing with a normal chest radiograph should undergo bronchoscopy.

Congenital heart disease can be a source of profuse bleeding in a child. With the advent of corrective cardiac surgery, the incidence of hemoptysis in this setting has declined significantly. Hemoptysis associated with CHD occurs most frequently with pulmonary vascular obstructive disease; it can also occur in conjunction with enlarged collateral bronchial circulation. Hemoptysis may be caused by erosion of a tortuous dilated bronchial artery into a bronchus, from rupture of an atherosclerotic bronchial artery plaque, or from localized pulmonary infarction at the bronchopulmonary anastomosis.¹³ The ensuing bleeding can be significant and potentially life-threatening. Massive hemoptysis from aberrant bronchial artery circulation occurred in 2 children in this series. With timely arteriography, the abnormal vessels were identified and embolized.

Pulmonary hemosiderosis is a rare, but important, cause of pulmonary hemorrhage in children. The idiopathic form is more prevalent in childhood, although PH also may be associated with an allergy to cow's milk (Heiner syndrome). The recurrent episodes of diffuse pulmonary hemorrhage present as hemoptysis.¹⁴ Chest radiography shows bilateral alveolar infiltrates during an acute episode. Many children have accompanying iron-deficiency anemia secondary to hemosiderin iron deposition in the alveoli. Bronchoscopy with bronchoalveolar lavage identifying hemosiderin-laden macrophages confirms the diagnosis. The disease process responds to corticosteroids or immunosuppressive therapy.¹⁵ Both patients in this series with PH presented with recurrent hemoptysis, bilateral pulmonary infiltrates, and anemia. Their conditions were appropriately diagnosed through bronchoscopy with bronchoalveolar lavage. Tapered prednisone therapy resulted in resolution of hemoptysis in both children.

Factitious hemoptysis is considered in the differential diagnosis if no etiology is discernible after a thorough evaluation, especially when the medical history or the patient's behavior is unusual.¹⁶ Sood et al¹⁷ reported on 3 cases of factitious hemoptysis in children. Covert biting of the buccal mucosa was attributed to hematemeses or hemoptysis in all of these patients. The hemoptysis in 1 child in our series was diagnosed as factitious. This child underwent a thorough investigation, including oral cavity examination, nasopharyngoscopy, bronchoscopy, and esophagoscopy, on 2 occasions. No source of the bleeding was identified until he was noted to have peculiar ulcerations on the lower lip; the family reported these to be self-inflicted. During the second evaluation, biopsy of the lip mucosa was also performed. The pathologic examination revealed squamous mucosa with chronic inflammation. Further discussion with the family raised the possibility of lip biting and bleeding as the cause of his symptoms. The child was subsequently referred for psychological counseling.

Neoplasia of the respiratory tract is a common cause of hemoptysis in adults. Although rare in children, endobronchial or pulmonary parenchymal tumors may cause significant bleeding. Tumors that may cause hemoptysis include bronchial carcinoid, bronchial adenoma, endobronchial metastasis, mediastinal teratoma, or bronchogenic carcinoma.¹⁸ In 1 child in this review who presented with significant hemoptysis, bronchoscopy identified a right middle lobe polypoid, bronchial mass. Endoscopic removal and topical oxymetazoline application controlled the hemorrhage. The histopathologic examination was diagnostic of respiratory mucosa with chronic inflammation. Interestingly, no neoplastic tissue was found in the permanent sections.

One child in this series was diagnosed as having erosive esophagitis by endoscopy. This case highlights the importance of differentiating between hemoptysis and hematemeses. Symptoms related to reflux esophagitis were described by this patient, but hemoptysis could not be definitively excluded. Because he had a cutaneous hemangioma, he underwent bronchoscopy to rule out airway hemangiomas. Subsequent esophagoscopy revealed esophagitis, which has improved with antireflux therapy and omeprazole.

Hemoptysis is relatively common in patients with cystic fibrosis, especially with increased survival into adulthood with the advances in medical treatment. Approximately 5% of patients with cystic fibrosis may present with massive hemoptysis due to bronchiectasis.¹⁹ Hyperplasia, tortuosity, and dilatation of bronchial arteries occur in these patients. In addition, multiple anastomoses form between the bronchial and pulmonary circulations following chronic lung inflammation. Hemorrhage results from erosion of these dilated, thin-walled bronchial vessels after successive pulmonary infections. Selective bronchial embolization may be required in cases of massive or recurrent hemoptysis.²⁰ The patient with cystic fibrosis in this series did not experience significant bleeding at presentation. The cystic fibrosis exacerbation was controlled with antibiotic and corticosteroid therapy.

DIAGNOSIS

Hemoptysis in children is evaluated systematically. The investigation begins with a detailed medical history and physical examination. Hemoptysis is first differentiated from other common sources of bleeding, including the upper airway and the gastrointestinal tract. One should quantify the amount of hemoptysis. The physician inquires about the possibility of foreign body ingestion, including choking or coughing episodes and new-onset wheezing. The possibility of trauma, especially in children who are tracheostomy-dependent, is evaluated. A history of chronic lung disease or CHD is also important. This is followed by a thorough examination of the head and neck. Special attention is given to the oral cavity and nasopharynx as potential sources of bleeding. Fiberoptic laryngoscopy is performed in cooperative children to evaluate the pharynx and larynx. Lung auscultation may reveal localized wheezing, suggesting an airway foreign body, or rales or decreased breath sounds, which may be associated with an infectious process.

A complete blood count with platelets is performed in all children with hemoptysis. This is imperative because children generally tend to swallow blood and the amount of bleeding is likely to be underestimated. Anemia requiring transfusion was identified in 3 patients in our series by this simple screening test. A workup, including prothrombin time and partial thromboplastin or bleeding time, may be ordered when coagulopathy is suspected. Because an infectious etiology is common, sputum is evaluated for bacterial, fungal, and mycobacterial organisms.²¹ Sputum culture can help identify the pathogens involved in pneumonic processes and direct therapy by providing microbial sensitivity to antibiotics.

Chest radiography can serve as a valuable screening study. Findings of focal or interstitial infiltrates may help support the diagnosis of infection. Unilateral air trapping with hyperinflation may suggest the diagnosis of an unsuspected tracheobronchial foreign body.² Other helpful findings include pulmonary nodules, hilar adenopathy, pleural effusion, and cardiomegaly. Approximately one third of chest radiographs may be normal in children with hemoptysis, although a tracheobronchial source may be eventually identified in about half of those with normal chest radiographs.²⁰ Chest radiography was performed in 15 of the 19 patients in this review. The diagnostic yield was 53%, with the chest radiograph showing abnormalities in 8 patients.

Computed tomography can be used to help further delineate chest radiographic findings. Intravenous contrast can be helpful in differentiating between vascular structures and solid masses.³ This is not recommended as an initial screening tool. Three chest computed tomography scans were performed in our study; 2 were reported as showing no abnormalities. The third scan demonstrated undifferentiated bronchiectatic vs emphysematous changes in the left lower lobe. Bronchoscopy revealed tracheobronchitis in this child.

If the etiology of hemoptysis is not discovered after the aforementioned workup and if the bleeding is recurrent or substantial, endoscopy is indicated to identify the source of bleeding. Endoscopy of the tracheobronchial tree may be performed by fiberoptic or rigid bronchoscopy.^{1-3,7-9,20} Fiberoptic bronchoscopy can be performed with sedation and allows for more detailed evaluation of the distal bronchial tree in older children. However, fiberoptic bronchoscopy does not permit effective ventilation and removal of blood clots.⁸ Rigid bronchoscopy offers several advantages. The rigid bronchoscope facilitates ventilation and helps localize the site of bleeding. Unlike the fiberoptic bronchoscope, the rigid bronchoscope is less likely to be obstructed by blood and, thus, allows for superior visualization of the tracheobronchial tree. Rigid bronchoscopy is ideal for suctioning the airway in cases of substantial airway bleeding and is more effective for removal of airway foreign bodies.²²

Rigid bronchoscopy was performed 24 times in 18 patients in this series for diagnostic and therapeutic reasons. Initial bronchoscopy showed abnormalities, including blood, mucosal inflammation, purulence, tracheal abrasions, granulation tissue, and bronchial mass, in 11 patients. One patient had no airway abnormalities, but the bronchoalveolar lavage identified hemosid-

erin-laden macrophages. No abnormalities were found in 6 patients, whose diagnoses were unknown (4 patients), factitious (1 patient), and esophagitis (1 patient). The diagnostic yield for bronchoscopy was 61%. This compares favorably with the diagnostic yields of the other major studies,^{1,8,9} ranging from 40% to 100%.

TREATMENT

Management of the child with hemoptysis is based on 2 important issues: the underlying cause and the severity of the bleeding. Most cases are self-limited and will resolve without intervention. No treatment was required in 6 children in this series. If a specific etiology is identified, treatment is directed to correct the underlying cause. Pulmonary infections are treated with appropriate antibiotics. Cystic fibrosis exacerbations are managed with antibiotic and corticosteroid therapy. Idiopathic PH is treated with corticosteroids. Tracheostomy-related trauma is managed by modifying the suctioning technique, using soft red-rubber catheters, and humidification. An alternate shape or size of tracheostomy tube may be considered.

In a small number of cases, the child may present with life-threatening hemorrhage (>8 mL/kg every 24 hours or 600 mL every 24 hours). Massive hemoptysis can quickly progress to acute respiratory distress in a child. In these patients, aggressive multidisciplinary intervention is required to institute lifesaving measures.²³ In addition to the otolaryngologist, a pediatrician, anesthesiologist, pediatric intensivist, interventional radiologist, and thoracic surgeon may be needed to manage these children.

The foremost objectives are to protect the airway, maintain oxygenation, stop the hemorrhage, and maintain sufficient blood volume. This is critical because the child may drown in his or her own blood and secretions. The airway is secured with an endotracheal tube or rigid bronchoscope in cases of severe respiratory distress. Oxygen and mechanical ventilation can be initiated when the child becomes hypoxic. Intravenous fluids and blood products are given to prevent cardiovascular collapse from the exsanguination. The otolaryngologist plays a critical role with rigid bronchoscopy.^{1,8} Bronchoscopy protects the airway and helps localize the bleeding site. Blood and secretions are suctioned from the tracheobronchial tree. Topical vasoconstrictors, such as oxymetazoline or epinephrine, or iced 0.9% saline can be applied through the bronchoscope to curtail the bleeding.² In addition, endoscopic tamponade can be performed by balloon catheter or with bronchoscopic pressure.³

If the hemorrhage continues despite endoscopic measures, or if the bleeding site cannot be localized, emergency arteriography is carried out. Selective bronchial artery embolization is effective in the emergency management of life-threatening hemoptysis.^{20,24-26} Bronchial arteriography identifies the bleeding vessel; selective embolization with absorbable gelatin sponge, steel or platinum coils, or polyvinyl alcohol particles controls the hemorrhage.²⁷ Mal et al²⁵ reported that bronchial artery embolization resulted in immediate cessation of hemorrhage in 77% of the cases, with long-term control beyond 3 months achieved in 45% of patients. Stebbings and Lim²⁶ concluded that bronchial embolization was superior to medi-

cal management for resolution of life-threatening bleeding. The most serious complication of embolization therapy is neurologic damage due to embolization of the spinal arteries. However, the risk of spinal artery occlusion and infarction is low.²⁴

Two children in this series required selective bronchial artery embolization. Both were suspected of having aberrant bronchial circulation associated with CHD. Arteriography revealed multiple bronchial collaterals. The collaterals were embolized with absorbable gelatin sponge in the first case and with coil and polyvinyl alcohol particles in the second. The hemorrhage was promptly controlled in both cases, although 1 child developed recurrence of significant bleeding the following day. A second arteriography showed an additional bronchial collateral arising from the thyrocervical trunk. It was embolized with polyvinyl alcohol particles, and no other bleeding occurred during the hospitalization. He developed 2 separate episodes of bleeding 4 and 9 months later due to pneumonia and tracheobronchitis. Prompt resolution occurred with use of antibiotics both times.

If bronchial artery embolization fails to control hemoptysis, surgical management is considered. Hemoptysis of this magnitude carries a greater than 50% mortality without surgical intervention. Surgery is offered to patients able to withstand general anesthesia and pulmonary resection.²³ Immediate identification of the bleeding site by bronchoscopy is followed by resection of the bleeding source.²⁸ Segmentectomy or lobectomy is preferred to pneumonectomy, as the latter carries a much higher mortality rate. Garzon and Gourin²⁹ reported an 83% survival in 65 resections performed for massive hemoptysis in this setting.

CONCLUSIONS

Hemoptysis is a rare but potentially life-threatening symptom of underlying respiratory tract abnormality in children. An efficient systematic evaluation is imperative to identify the underlying etiology; infection and tracheostomy-related trauma were the 2 most common causes in this review. The workup may include complete blood count, coagulation studies, sputum cultures, chest radiography (including computed tomography and arteriography), and bronchoscopy, as indicated by the individual circumstances. The otolaryngologist plays a pivotal role in the diagnosis and management by flexible endoscopy of the nose, nasopharynx, and larynx, and through the use of the rigid bronchoscope, especially in cases of massive hemoptysis.

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