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Massive Hemoptysis

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A 77-year-old man with underlying bronchogenic cancer of the right lung presented to the emergency department with complaints of coughing up blood-streaked sputum for 3 days, followed by expectoration of a large volume of bright red blood just prior to presentation. His past medical history was pertinent for advanced chronic obstructive pulmonary disease, type 2 diabetes mellitus, hypertension, peripheral vascular disease, and hyperlipidemia. He was noticeably dyspneic and in extremis. Blood pressure was consistent with circulatory shock (mean arterial pressure, 50 mm Hg), and oxygen saturation was diminished at 85% despite 100% facemask oxygen therapy. The patient was intubated with a size 8 endotracheal tube and placed on mechanical ventilation. He received 1 L of 0.9% saline and intravenous dopamine for blood pressure support. Physical examination revealed diminished breath sounds in the right lung. Laboratory studies revealed the following: hemoglobin, 9.3 mg/dL; platelets, $245 \times 10^3/\mu\text{L}$; prothrombin time, 10.6 seconds; partial thromboplastin time, 38 seconds; and normal renal function parameters. A chest radiograph noted the lung mass and associated alveolar hemorrhage. The patient was admitted to the intensive care unit with a diagnosis of massive hemoptysis and evaluated by the pulmonologist. Due to the patient's advanced lung disease and lung cancer, aggressive surgical therapy was not an option. The family decided to pursue comfort measures, and intravenous morphine was administered. The patient died within the next 6 hours.

Hemoptysis is a potentially life-threatening manifestation of underlying lung disease. It is essential to recognize the severity of bleeding (massive versus nonmassive) in patients who present with hemoptysis and determine the potential causes so that appropriate interventions can be initiated. This article reviews the diagnosis and management of massive hemoptysis.

DEFINITION AND NATURAL HISTORY

Hemoptysis is the expectoration of gross blood or blood-streaked sputum. Hemoptysis is classified as massive or nonmassive based on the rate of bleeding. Expectoration of less than 100 mL of blood in a 24-hour period is considered nonmassive hemoptysis. The definition of massive hemoptysis varies widely in the literature, ranging between 100 and 600 mL of blood in a 24-hour period; however, the most commonly used definition is 600 mL in 24 hours.¹ It is estimated that more than 400 mL of blood in the alveolar space is sufficient to cause impairment of oxygenation.²

Most cases of hemoptysis, both massive and nonmassive, are self-limited and resolve spontaneously. In a survey study of 230 chest physicians, 86% indicated that they had treated patients with massive hemoptysis dur-

ing the previous year, and 28% reported death from pulmonary hemorrhage.³ Asphyxia rather than exsanguination is usually the cause of death,⁴ and it is commonly accompanied by cardiovascular collapse. The death rate from untreated massive hemoptysis ranges from 30% to 85% in multiple studies.^{1,5-8} Among patients who survive the initial hemorrhagic episode, bleeding ceases in 75% of cases within 24 hours, and in all cases by day 5.⁹

DIFFERENTIAL DIAGNOSIS

Acute bronchitis is the most common cause of nonmassive hemoptysis (Table 1). Other frequent underlying causes of nonmassive hemoptysis include bronchiectasis, pulmonary tuberculosis, and lung cancer. Although there is overlap, massive hemoptysis is more often due to advanced bronchiectasis, lung cancer, pulmonary tuberculosis (that erodes into a large vessel), and lung abscess. The etiology largely depends on the

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TAKE HOME POINTS

- Massive hemoptysis, defined as expectoration of more than 100 mL of blood from the lung in a 24-hour period, requires admission to the intensive care unit.
- A first step in diagnosing hemoptysis is to determine the bleeding source: respiratory tract versus a nasopharyngeal or gastrointestinal tract source. Querying the patient identifies the correct source in 50% of cases.
- Massive hemoptysis is managed in a stepwise fashion: protect the airway and stabilize the patient, localize the bleeding site, and administer specific therapy.
- A chest radiograph localizes bleeding in 60% of cases and is equivocal in 15%.
- Flexible bronchoscopy facilitates localization of the bleeding site, suctioning of the airway, and administration of site-specific therapy.
- Surgical management of massive hemoptysis is definitive in selected candidates if the lesion can be localized.

demography of the population sample. Bronchogenic carcinoma and chronic inflammatory lung disease are the most common causes of massive hemoptysis in the United States. Tuberculosis remains the leading cause of massive hemoptysis worldwide.¹⁰ Less common causes include aspergillomas, bronchial adenomas, chest trauma, pulmonary arteriovenous malformations, cocaine-induced lung injury, pulmonary embolism, cardiac mitral valve stenosis, pulmonary alveolar hemorrhage syndromes, and cystic fibrosis. As patients with cystic fibrosis live longer, complications such as massive hemoptysis are becoming increasingly common. In a retrospective cohort of 28,853 patients with cystic fibrosis observed over 10 years, the incidence of massive hemoptysis was 0.87%, and the overall prevalence was 4.1%.¹¹ More recently, iatrogenic causes of massive hemoptysis have increased in frequency; these include bleeding following a transbronchial biopsy or transthoracic needle biopsy or bleeding from a ruptured pulmonary artery caused by Swan-Ganz catheter placement.

DIAGNOSIS

History and Physical Examination

Hemoptysis must first be differentiated from hematemesis and epistaxis. Hemoptysis is characterized by

Table 1. Etiology of Hemoptysis

Infection: chronic inflammatory lung disease (ie, acute/chronic bronchitis), bronchiectasis (including cystic fibrosis), lung abscess, aspergilloma, tuberculosis
Neoplasm: bronchogenic carcinoma, pulmonary metastases, bronchial adenoma, sarcoma
Foreign body/trauma: broncholith, aspirated foreign body, tracheovascular fistula, chest trauma
Cardiac/pulmonary vascular: left ventricular failure, mitral valve stenosis, pulmonary embolism/infarction, pulmonary artery perforation (complication of pulmonary artery catheter)
Alveolar hemorrhage: Goodpasture's syndrome, systemic vasculitides/collagen vascular disease, drugs (nitrofurantoin, isocyanate, trimellitic anhydride, D-penicillamine, cocaine), coagulopathy
Iatrogenic causes: post-lung biopsy, ruptured pulmonary artery from Swan-Ganz catheter
Other: pulmonary arteriovenous malformation, bronchial telangiectasia, pneumoconiosis

cough with frothy sputum that is alkaline when tested by litmus paper. In contrast, hematemesis originates from the gastrointestinal tract, is accompanied by nausea and vomiting, and is frequently acidic. Epistaxis is usually traumatic and may be localized by anterior rhinoscopy and examination of the oropharynx. Aspirated blood or swallowed blood from any of the sites can make it difficult to initially identify the origin of bleeding. Upon clinical presentation, only 30% of patients spontaneously report the site of bleeding. However, when queried, patients are highly accurate in predicting the bleeding site (50% of the time), while physical examination by a physician identifies the origin of bleeding only 43% of the time and is equivocal 25% of the time.¹ Therefore, all patients with hemoptysis should be asked about the site of the bleeding.⁵

The clinical history and physical examination help to narrow the differential diagnosis. In a patient with known pulmonary tuberculosis, the source of the bleeding may be a pulmonary artery aneurysm (Rasmussen's aneurysm) in an old cavitory lesion. In smokers older than 40 years, bronchogenic carcinoma is more prevalent and should be considered. A history of deep vein thrombosis suggests pulmonary infarction and/or embolism. Travelers or immigrants from Asia, the Middle East, and South America may develop hemoptysis as an initial manifestation of paragonimiasis and hydatiform cysts. Cyclical hemoptysis occurring during a menstrual cycle suggests the diagnosis of catamenial hemoptysis. On physical examination, saddle nose with rhinitis and septal perforation are signs of Wegener's granulomatosis. Stridor raises the

possibility of tracheal tumors or a foreign body. Oral and aphthous ulcers, genital ulcers, and uveitis are suggestive of Behçet's disease, in which pulmonary arteriovenous malformations are responsible for hemoptysis. Digital clubbing may be seen in bronchiectasis, tuberculosis, and lung carcinoma.¹⁰

Laboratory and Imaging Studies

Studies that should be obtained in patients with significant bleeding or recurring hemoptysis include measurement of hemoglobin and hematocrit (to assess the magnitude and chronicity of bleeding), coagulation studies (including international normalized ratio, partial thromboplastin time), and platelet count (to exclude thrombocytopenia or another coagulopathy), urinalysis, and renal function tests (to exclude pulmonary-renal syndromes such as vasculitis, Goodpasture's syndrome, or Wegener's granulomatosis). Routine laboratory data, however, are usually not helpful in the diagnosis or management of hemoptysis, except in the presence of a coagulopathy or thrombocytopenia. In these circumstances, bleeding can be more severe and laboratory data are crucial when initiating appropriate therapy.

A chest radiograph is useful in localizing the bleeding source if there is a lung mass, cavitary lesion, or alveolar hemorrhage.^{12,13} In general, a chest radiograph localizes bleeding in 60% of cases and is equivocal in 15%.¹⁴ Chest computed tomography (CT) scanning in conjunction with other diagnostic tests localizes the lesion in 63% of cases.⁸ Thoracic CT scans with contrast may detect aneurysms and arteriovenous malformations or bronchiectasis not visible on routine chest radiograph. Therefore, except for life-threatening situations, thoracic CT scans should be performed prior to bronchoscopy.

Bronchial artery angiography (standard or selective) is highly effective in localizing the source of bleeding and identifying a vessel for embolization¹⁵ (**Figure 1**). The bronchial arteries supply the proximal airways, such as the trachea and mainstem bronchi, whereas the pulmonary circulation supplies the intrapulmonary airways and alveoli. The bronchial circulation (a high pressure circuit with systolic pressure of 120 mm Hg) is the most common source of massive hemoptysis, accounting for 95% of all cases. Less than 5% of bleeding arises from the pulmonary circulation (a low pressure circuit with a systolic pressure of 15–20 mm Hg).^{16,17} If bronchial artery angiography does not reveal a bleeding vessel, a pulmonary angiogram is required to investigate the pulmonary circulation.¹⁶ Bronchial arteriography is highly sensitive in identifying a source of bleeding, but this imaging modality is invasive and time consuming and



Figure 1. Bronchial arteriogram. Left bronchial arteriogram in a patient with massive hemoptysis revealing bronchial artery enlargement and hypervascularity.

only employed when other diagnostic techniques have failed.¹⁸

There are no specific independent risk factors that predict the onset or the extent of hemoptysis. However, the presence of cavitation on radiologic examination and perihilar location of a pulmonary infiltrate may predict recurrence after a sentinel event of hemoptysis. Pulmonary artery aneurysm within such cavitary lesions (Rasmussen's aneurysm) may occur as a result of erosion of the blood vessel, predisposing the patient to massive bleeding.¹⁹

MANAGEMENT

All patients with massive hemoptysis should be admitted to the intensive care unit (ICU) to allow closer monitoring of hemodynamic status and assessment of the magnitude of blood loss. Patient management should be undertaken in a stepwise fashion: (1) airway protection and patient stabilization, (2) localization of the bleeding source, and (3) administration of specific therapy (**Table 2**). Initial management is undertaken by the medical team in most cases, with surgical intervention warranted in certain circumstances.

Step 1 includes admission to the ICU, maintenance of an adequate airway, administration of supplemental oxygen, correction of coagulopathy, fluid resuscitation, and attempts to localize the bleeding source. If the airway is compromised or if bleeding continues, the patient should be intubated by an experienced physician. A size 8 or larger caliber endotracheal tube (ETT)

Table 2. Management of Massive Hemoptysis

Steps	Recommendations	Options	Comments
Protect airway and stabilize patient	Admit to intensive care unit and monitor		Allows monitoring of hemodynamics and magnitude of blood loss
	Maintain adequate airway	Consider double-lumen tube	Facilitates suctioning and FB
		Consider unilateral intubation	FB can verify placement of double-lumen ETT
	Supplemental oxygen		
	Fluid resuscitation	IV vasopressin	
Lateralize bleeding site (bleeding side down)	History and physical examination		
	Radiology	Chest radiograph and CT	
	Bronchoscopy	Flexible or rigid bronchoscopy	Early bronchoscopy to identify, locate, and guide therapy
Administer specific therapy	Bronchoscopic therapy	Iced saline lavage	Size 4–7 Foley catheter
		Topical agents: epinephrine, thrombin, fibrinogen	
		Endobronchial tamponade for endobronchial lesions	
		Laser photocoagulation for alveolar hemorrhage	
	Pharmacologic therapy	Vasopressin, steroids	
	Angiography and embolization		Semi-definitive therapy or bridge to surgery
	Surgical resection	Segmentectomy, lobectomy, pneumonectomy	Embolization unfeasible, failed embolization, unstable patient, pulmonary artery hemoptysis, mycetoma
Radiation therapy		Aspergilloma, vascular tumors	

CT = computed tomography; ETT = endotracheal tube; FB = flexible bronchoscopy; IV = intravenous.

should be used to permit subsequent bronchoscopic localization of bleeding, adequate suctioning of the airway, and specific endobronchial therapy. A Carlin's double-lumen ETT facilitates lung separation, suctioning of blood, and localization of the bleeding site with concurrent flexible bronchoscopy (**Figure 2**). The double-lumen tube also can be left in place for 24 hours without the bronchoscope, allowing time for the bleeding to stop. Some authors discourage the use of the double-lumen ETT due to difficulty in placement, increased rates of tube dislodgement, and increased rates of postoperative pneumonia and ischemic mucosal injury.²⁰

Step 2 includes bronchoscopy to localize the bleeding site and suction the airway.²¹ Bronchoscopy has been reported to successfully localize bleeding in 49% to 92.9% of cases of massive hemoptysis.^{21,22} The yield of bronchoscopy is greater if the procedure is performed in the first 24 hours after the onset of bleeding. However, the ideal timing of bronchoscopy is con-

troversial. The consensus is to perform immediate bronchoscopy in patients with rapid clinical deterioration and delay bronchoscopy for up to 48 hours in stable patients. Most pulmonologists use a flexible bronchoscope in patients with massive hemoptysis because it is easy to use at the bedside and can reach distal lesions. Others prefer rigid bronchoscopy because of its greater ability to suction blood and secretions and maintain airway patency; however, its inability to visualize the upper lobes or peripheral lesions remains a major limitation.^{17,21} Once the bleeding is localized, the patient should be placed in a dependent position with the bleeding side down to prevent aspiration.²³

Step 3 involves administration of specific therapy. Flexible bronchoscopy permits directed therapy using iced saline to lavage the involved lung^{21,24,25} and administration of topical hemostatic agents, such as epinephrine or thrombin-fibrinogen.²⁶ Ice-saline lavage of up to 1000 mL in 50-mL aliquots at the bleeding site has

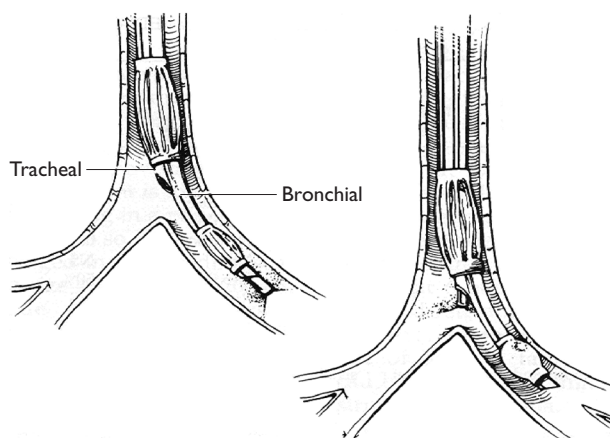


Figure 2. Double-lumen endotracheal tube for endobronchial tamponade. It has a bronchial lumen, which is placed in the left main bronchus to ventilate the left lung, and a tracheal lumen, which remains supracarinal and ventilates the right lung while preventing occlusion of the right upper lobe orifice. The external lumina are connected to the ventilator using a Y connector device. Left- and right-sided double-lumen tubes are available. (Adapted with permission from Dellinger RP. Fiberoptic bronchoscopy in adult airway management. *Crit Care Med* 1990; 18[8]:884.)

been shown to be up to 90% effective in stopping bleeding in some studies.^{17,21,23} There are no specific recommendations based on the literature on the choice of agent for site-specific therapy, as most case reports are uncontrolled observational studies. Other alternative site-specific therapies using the flexible bronchoscope include endobronchial tamponade using a balloon tamponade catheter to prevent aspiration to the unaffected contralateral lung and preserve gas exchange (**Figure 3**).^{20,21} A bronchus-blocking balloon catheter has been designed to be used through the working channel of the flexible bronchoscope^{20,27} and has a second channel that is used to instill vasoactive-hemostatic agents such as ice saline, epinephrine, vasopressin, or thrombin-fibrinogen to control bleeding.^{17,20,26,28} Once bleeding has ceased, the balloon may be deflated, the catheter removed, and the patient referred for subsequent therapy.

Nonbronchoscopic medical management is used to treat massive hemoptysis if endobronchial therapy fails; this includes bronchial artery embolization with or without adjunctive pharmacologic therapy with intravenous vasopressin. Bronchial artery embolization achieves immediate control of bleeding in 75% to 90% of cases.^{15,18} Postembolization recurrence of hemoptysis has been observed in 20% of cases.²⁹

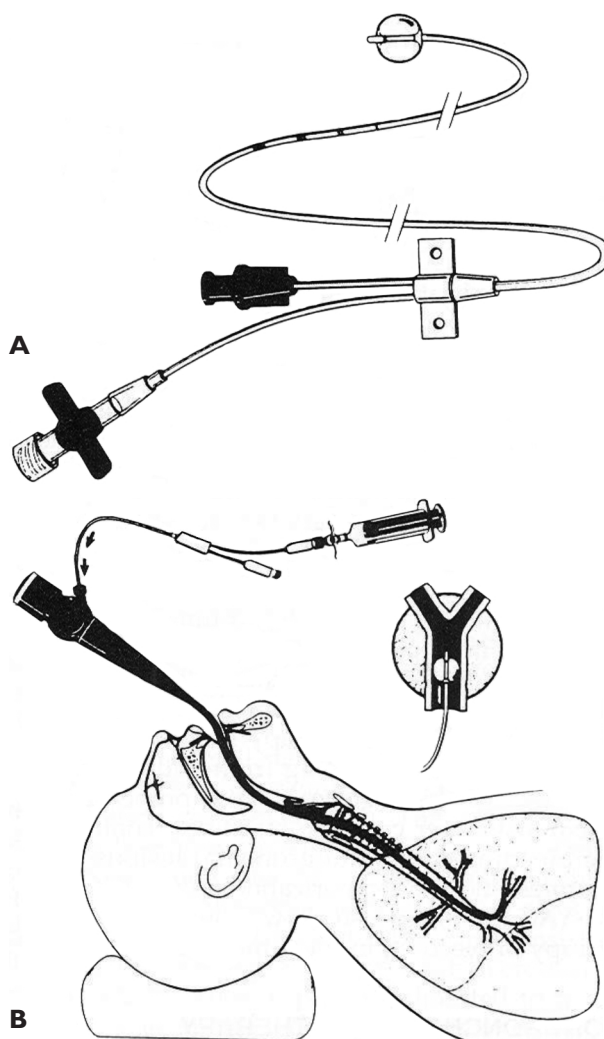


Figure 3. (A) Fogarty balloon embolectomy catheter with balloon inflated and (B) Fogarty balloon embolectomy catheter inserted through the channel of the fiberoptic bronchoscope with balloon inflated after insertion (Adapted with permission from Patel SR, Stoller JK. The role of bronchoscopy in hemoptysis. In: Wang KP, Mehta AC, editors. *Flexible bronchoscopy*. Cambridge: Blackwell Scientific; 1995:315. Copyright © 1995, Blackwell Publishing Ltd.)

Surgical Management

Surgery is indicated if bronchial artery embolization is unavailable or technically unfeasible or if bleeding or aspiration of blood continues despite embolization. Surgical resection of the bleeding site is possible if the lesion can be localized and the patient is a surgical candidate. Surgery is also preferable when the acuity (rate and amount of bleeding) of hemoptysis precludes safe bronchial artery embolization. More specific indications

for surgery in massive hemoptysis include persistent bleeding from a mycetoma resistant to medical management, bronchial adenoma, iatrogenic pulmonary artery rupture, leaking aortic aneurysm, hydatid cysts, and selected arteriovenous malformations.¹⁹ Surgery is contraindicated in patients with lung carcinoma involving the trachea, mediastinum, heart, great vessels, or parietal pleura; active tuberculosis; cystic fibrosis; multiple arteriovenous malformations; multifocal bronchiectasis; diffuse alveolar hemorrhage; and poor cardiopulmonary reserve.¹³ Spirometry when available is a more accurate predictor of surgical risk (forced expiratory volume in 1 second < 50%) than dyspnea.

The extent of surgical resection is influenced by several factors, including preoperative pulmonary function, site of bleeding, and severity of blood loss. A final decision on the timing and extent of surgery in massive hemoptysis must be individualized. For example, a proximal tumor makes a limited resection unfeasible and a pneumonectomy more likely. An emergency pneumonectomy may be indicated independent of pulmonary function if the blood loss is severe, if bronchial artery embolization is not available, and if endovascular treatment has failed. Less than 10% of patients with massive hemoptysis require emergent surgery; in these patients, 20% mortality and 25% to 50% morbidity have been reported.¹⁹

There are no recent randomized studies directly comparing medical versus surgical treatment in patients with massive hemoptysis. Observational studies comparing mortality rates between medical and surgically treated patients are limited by selection bias, variation in patient selection, and variations in medical and surgical therapy. More importantly, none of the series used bronchial artery embolization as part of medical management. Current recommendations about medical versus surgical therapy for massive hemoptysis must be individualized.

CONCLUSION

Massive hemoptysis is a serious manifestation of underlying pulmonary disease. The major etiologies have not changed through the years, with bronchiectasis, lung cancer, pulmonary tuberculosis, and lung abscess constituting the majority of cases. A stepwise approach to treatment that includes stabilization of the patient, identification of the bleeding site, and bronchoscopic evaluation and therapy is recommended. Arteriography of the bronchial vessels with embolization is effective if endobronchial therapy fails in constricting bleeding and is a bridge towards definitive therapy. **HP**

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