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[Reviews]

Clinical assessment and management of massive hemoptysis

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▼ Abstract

Objective: Massive hemoptysis is a potentially lethal condition that deserves to be investigated thoroughly and brought under control promptly. The mortality rate depends mainly on the underlying etiology and the magnitude of bleeding. Although the diagnosis of hemoptysis may be established by chest radiograph, many pathologies may be missed. Because bronchoscopy and computed tomography are complementary, they may indicate pathologies not detectable by chest radiograph. Finding the etiology and site of the hemoptysis is imperative.

Investigations: Urgent bronchoscopy should be performed in unstable patients because it exerts a paramount role in the diagnostic search and therapy. It can be used to facilitate the introduction of balloon-tip catheters into the bleeding bronchus for tamponade of the hemorrhagic artery, protecting *de facto* the contralateral lung or nonbleeding bronchi from blood aspiration. Endobronchial tamponade should only be used as a temporary measure until a more specific treatment is instituted. In stable patients, computed tomography should be ordered before any bronchoscopic exploration.

Interventions: Surgery was once regarded as the treatment of choice in operable patients with massive hemoptysis. Bronchial artery embolization (BAE) is an excellent nonsurgical alternative; it is proven to be very effective and lacks the mortality and morbidity encountered in surgical interventions. Nevertheless, surgery is recommended in patients with massive hemoptysis caused by thoracic vascular injury, arteriovenous malformation, leaking thoracic aneurysm with bronchial communication, hydatid cyst, and other conditions in which BAE would be inadequate.

Medical Management: Conservative medical therapy may suffice in certain conditions, like bronchiectasis, coagulopathies, Goodpasture's syndrome, and acute bronchopulmonary infections. Preparation for other interventions (endobronchial tamponade, BAE, or surgery in eligible candidates) should be undertaken if the bleeding fails to respond to conservative measures. Supportive therapy should be applied vigorously to all patients with massive hemoptysis.

Most hemoptysis are more frightening than life-threatening. However, massive hemoptysis warrants prompt medical intervention because of reduced alveolar gas exchange and the unstable hemodynamic condition that may ensue. The definition of massive hemoptysis varies widely in the literature, from 200 mL to 1000 mL/24 hrs (1, 2); but the expectoration of ≥ 600 mL in 24 hrs is what most authors use in clinical reports to define massive hemoptysis (3). It is estimated that 400 mL of blood in the alveolar space is sufficient to cause significant hindrance to the oxygen transfer (4), although only minor changes in the vital signs will be noted for the same amount of blood loss (5).

The degree of bleeding, although exaggerated by the patient, may be underrated because the volume of blood engulfing the involved lobes or lungs is not quantitated and may be significant. The major challenge facing the clinician is not only to establish the site or cause of the hemoptysis, but also to control the bleeding; most often, the latter depends on the cause.

ETIOLOGIES

The most common etiologies of massive hemoptysis are listed in Table 1. The frequency of some etiologies varies with the demography of the population sample. Chronic inflammatory lung diseases and bronchogenic carcinoma remain the most common causes of hemoptysis encountered in medical practice in the United States (6). Tuberculosis continues to be the leading cause of hemoptysis worldwide because of its prevalence in Third World countries. It is estimated that two billion people, one third of the world population, are infected by the tuberculosis bacillus and ~5% to 10% of those infected will develop the disease (7).

Neoplasm:

- 1) bronchial carcinoma, adenoma
- 2) metastatic lung cancer

Bronchiectasis

Infections:

- 1) mycobacteria, especially tuberculosis
- 2) fungal infections
- 3) lung abscess, necrotizing pneumonia
- 4) paragonimiasis
- 5) hydatid cyst

Vascular:

- 1) pulmonary infarct, embolism
- 2) mitral stenosis
- 3) iatrogenic rupture of pulmonary artery by balloon-tipped catheter
- 4) broncho-arterial fistula
- 5) ruptured thoracic aneurysm
- 6) arteriovenous malformation

Vasculitis:

- 1) Behcet's disease
- 2) Wegener's granulomatosis

Miscellaneous:

anticoagulant therapy, coagulopathies (von Willebrand's disease, hemophilia, thrombocytopenia), Goodpasture's syndrome, trauma, lymphangioleiomyomatosis

Table 1. Most common causes of massive hemoptysis

The source of the bleeding should be established and hemorrhagic sites from the nasopharynx or the gastrointestinal tract should be excluded. The great majority of hemoptysis prevalence originates from the bronchial arteries (90%), whereas the pulmonary arteries may be the cause in only 5% (8). Bleeding tends to be more significant when coming from the bronchial arteries because of high systemic pressure. Massive hemoptysis accounts for only 1.5% of all hemoptysis (9) and is more prevalent in certain conditions, such as tuberculosis, carcinoma, fungal ball, bronchial communication with a leaky aortic aneurysm, Goodpasture's syndrome, Behcet's disease, arteriovenous malformations, trauma, coagulopathies, and lymphangioleiomyomatosis. Nevertheless, any bleeding originating from the bronchial arteries, even mild, has the propensity to cause life-threatening hemoptysis because of the high pressure in the bronchial arteries.

CLINICAL HISTORY

A good history will greatly help to corner the diagnosis. Vigorous anticoagulant therapy or coagulopathies may cause hemoptysis in patients with no prior history of lung diseases or hemoptysis (10, 11). Patients with known pulmonary tuberculosis may bleed from Rasmussen's aneurysm caused by erosion of blood vessels deprived of lateral support or by bronchopulmonary anastomosis within the wall of old cavities (12). Aspergilloma should be included in the differential diagnostic work-up in patients with prior diagnosis of cavitary or bullous diseases such as tuberculosis, fungal infections, sarcoidosis, or chronic obstructive pulmonary diseases (13). Bronchogenic carcinoma should be high in the list among smokers >40 yrs of age (14).

Bronchial adenoma, vascular anomalies, and aspiration of foreign bodies are very common causes of hemoptysis among children; over half of all bronchogenic neoplasms in children are bronchial adenoma (15-17). Patients with congestive heart failure secondary to mitral stenosis are at risk for hemoptysis (18). A history of deep vein thrombosis should lead the clinician toward the diagnosis of pulmonary infarct and embolism. Febrile conditions with pulmonary infections (lung abscess, necrotizing pneumonia) may be complicated by massive hemoptysis (14).

Travelers or immigrants from Asia, the Middle East, and South America may experience hemoptysis as initial manifestation of parasitic infections, such as paragonimiasis and cystic hydatiform (19, 20). The concurrent development of hemoptysis and menstrual cycles secures the diagnosis of catamenial (endometriosis) hemoptysis (21). A clinical presentation of spontaneous pneumothorax and hemoptysis with a diffuse interstitial pattern in the chest radiograph should raise the possibility of lymphangioleiomyomatosis in a childbearing-age woman (22).

PHYSICAL EXAMINATION

The physical examination may provide valuable clues leading toward the diagnosis. A saddle nose with rhinitis and septal perforation are signs of Wegener's granulomatosis (23). The presence of stridor or wheezing should raise the suspicion of tracheolaryngeal tumors or foreign body. Oral or genital aphthous ulcerations, uveitis, cutaneous nodules, or pustules may be clinical presentations in patients with Behcet's disease; ~30% of patients with this condition will succumb to rupture of pulmonary artery aneurysm (24). The diagnosis of Goodpasture's syndrome should be pursued if blood is also detected in the urine, although the absence of hematuria does not exclude the diagnosis (25). Clubbing may be a sign of lung carcinoma or bronchiectasis.

DIAGNOSTIC STUDIES

Sputum Examination. Sputum should be examined for the presence of bacteria (Gram stain, potassium hydroxide, and acid-fast bacillus). Sputum smear for cytology should be done if the patient is >40 yrs of age and a smoker. Sputum specimen should also be obtained for culture, especially for mycobacterium and fungus.

Chest Radiography. Chest radiography is readily available and is a very important diagnostic tool in finding the cause of the bleeding. It helps to identify many lung parenchymal pathologies, such as cavitary lesions, tumors, infiltrates, atelectasis. Intra-alveolar bleeds may produce a fine reticulonodular pattern in the involved lobes that can be taken for a pneumonia (26). Chest radiography interpretations were normal or nonlocalizing in a substantial percentage of patients with hemoptysis, between 20% and 46%; these statistical variations were caused by the etiological factors in the respective studies greatly influencing the radiographic image (27, 28).

Bronchoscopy. Rigid bronchoscopy is recommended in the event of massive hemoptysis because of its greater suctioning ability and maintenance of airway patency. General anesthesia is commonly used with its application. Rigid bronchoscopy is also safe and well tolerated under local anesthesia and conscious sedation when performed by experienced hands (29). Failure to visualize the upper lobes or peripheral lesions remains a major limitation with rigid bronchoscope (30). Conversely, the fiberoptic bronchoscope can be performed at the patient's bedside and may reach lesions located at the fifth or sixth bronchial orifice (31).

Profuse amount of blood in the bronchi may render the localization of the hemorrhagic site very difficult, if not impossible, when probing the affected lung with the fiberoptic bronchoscope. Instillation of vasoactive drug (epinephrine diluted at 1:20,000) directly into the bleeding bronchus through the bronchoscope channel may eventually decrease or even stop the hemorrhage. This tactic may not be effective in presence of excessive bleeding, but a trial is always worthy. Finding the bleeding site does not necessarily establish the diagnosis.

The ideal time for bronchoscopy is controversial. The consensus is to perform urgent bronchoscopy in patients with rapid clinical deterioration; whereas delayed bronchoscopy, within 24-48 hrs of admission, is preferred in stable patients (32). Hypoxemia may occur during bronchoscopy; the oxygen flow should be adjusted to maintain adequate oxygen saturation.

Computed Tomography. Computed tomography (CT) may demonstrate lesions that may not be visible in the chest radiograph, such as bronchiectasis or small bronchial carcinoma (33). High-definition CT is now considered as the method of choice for the diagnosis of bronchiectasis (34). When performed with contrast material, CT may detect thoracic aneurysm or arteriovenous malformations (35). Except for life-threatening situations, CT should be performed before the bronchoscopic exploration. Nevertheless, hemoptysis will remain unexplained in 5% to 10% of patients despite all diagnostic work-up (4). In one series of 91 patients, no cause of the hemoptysis was found either by CT or bronchoscopy in up to 34% of the patients (36).

MANAGEMENT

Resuscitation and Supportive Measures. Vital signs and oxygen saturation should be monitored. Blood should be drawn for complete blood count, arterial blood gas, coagulation profile, electrolytes, blood typing and cross-match, and renal and liver function tests. A minimum of 6 units of packed red cells should be ordered because of the potential blood loss from the bronchial arteries. If the patient presented initially with unstable vital signs, uncrossed O-positive blood type should be transfused immediately; O-negative blood type should be reserved for childbearing-age females. All patients with massive hemoptysis should be monitored in the intensive care unit. Worsening hypoxemia is an indication of an expanded alveolar territory affected by the bleeding and should be corrected with high-flow oxygen. When intubation becomes necessary (life-threatening hemoptysis, hypovolemic shock, worsening of the hypoxemia in spite of supplemental oxygen, or elevated CO₂ concentration), a large bore endotracheal tube of ≥ 8 mm internal diameter is preferred to allow the fiberoptic exploration of the lungs.

The patient should be placed on lateral decubitus toward the site of bleeding in the prospect of sparing the contralateral lung from aspiration. This belief is rather theoretical and has not been challenged in controlled studies. Cough-suppressing drugs can be added as an adjunct therapeutic measure, but they may favor the hazard of blood retention into the lungs.

Surgery and Other Invasive Methods. Until 2 decades ago, the surgical approach was regarded as the treatment of choice once the bleeding site is identified by bronchoscopy (37, 38), but now **surgery is only one choice of treatment**. The surgical **mortality rate**, defined as death within 7 days of the operation, has varied between **1% and 50%** (39, 40). The criteria of eligibility for surgery differ among the institutions and seem to be subject to surgical or institutional bias.

Surgery is **contraindicated** in patients with **lung carcinoma** invading the trachea, the **mediastinum**, the heart, the great vessels, and the **parietal pleura**; in patients with terminal malignancy; and in patients with advanced pulmonary fibrosis (41). In the latter group, surgery itself is perilous because pneumonectomy or lobectomy will not be tolerated because of poor pulmonary reserve. Benefits should always be weighed against the risk of complications and morbidity in all potential surgical candidates, especially those with congestive heart failure or chronic obstructive pulmonary diseases. Surgery remains the procedure of choice in the treatment of massive hemoptysis caused by leaky aortic aneurysm, arteriovenous malformations, hydatid cyst, iatrogenic pulmonary rupture, chest injuries, bronchial adenoma, and fungal ball resistant to other therapeutic trials (38, 39).

The efficacy of systemic antifungal drugs in the treatment of aspergilloma-induced hemoptysis has been disappointing (42). The mortality rate in surgically treated patients with pulmonary aspergilloma varies from 1.5%, 7%, 9%, 14%, to 23% in reported series (43).

The instillation of antifungal drugs, amphotericin B with or without N-acetylcysteine, or iodine directly into the cavity via an indwelling catheter placed either percutaneously or transbronchially has given excellent control of hemoptysis (44, 45). This technique should be considered as a viable option in the treatment of massive hemoptysis in cavity-concealed aspergilloma, especially in poor surgical candidates.

Endobronchial Tamponade and Therapy. The technique of endobronchial tamponade for bleeding control in massive hemoptysis was first introduced by Hiebert in 1974 (46) by **occluding the bleeding bronchus with a balloon catheter**. The insertion of these catheters necessitates the use of a **rigid or flexible bronchoscope**. Large caliber catheters such as the **Foley** only fit through a **rigid bronchoscope**.

Unfortunately, **rigid bronchoscopes** can **only reach** the **main stem** bronchus. **Smaller caliber** catheters can be inserted deeper into the segmental bronchus under the guidance of a **flexible bronchoscope**. The **Fogarty catheter**, 4-Fr (80 cm long), can be easily passed through a **fiberoptic** bronchoscope with a **large inner** channel (≥ 2 mm). The balloon at the distal tip of the catheter is inflated into the bleeding segmental bronchus as a hemostat. The **distal hub** of the catheter is **cut off** to allow the removal of the bronchoscope by sliding it over the Fogarty catheter; the pressure in the balloon is secured by a straight pin inserted into the catheter lumen (47). Another technique is to place a **pulmonary artery flotation catheter next to the fiberoptic bronchoscope** and then advance the catheter to the hemorrhaging bronchial division (48). This technique requires the skill of an experienced bronchoscopist.

More recently, a **new double-lumen balloon catheter** was designed to pass **through a fiberoptic** bronchoscope (49). This catheter, 6-Fr (170 cm long), is better adapted to the flexible bronchoscope because the balloon can be inflated by a **detachable valve** at the proximal end, facilitating the removal of the bronchoscope without any modification to the catheter. This represents a **major advantage over the Fogarty catheter**. In addition, administration of **vasoactive drugs** is possible **through the second channel**. It was used successfully in 26 of 27 patients with hemoptysis, and it can be left in place for days while the patient undergoes other treatment modalities such as surgery, bronchial artery embolization, radiation, or chemotherapy. Nevertheless, endobronchial tamponade should be used as a temporary measure in life-threatening situations until a more specific treatment is instituted.

Other endobronchial methods have been used to control massive hemoptysis. Fibrin precursors were used as hemostatic agents via intrabronchial infusion through the fiberoptic bronchoscope wedged against the bleeding bronchus (50). Sporadic success has been reported by means of the photocoagulation properties of lasers (51). However, identification of the bleeding artery in the presence of massive hemoptysis remains a very difficult task, and delivery of the precision-guided laser beam may be hampered.

Double-lumen endotracheal tubes, such as Carlens (Willy Rusch, Waiblingen, Germany) or Robertshaw (Leyland, London, UK), have been used to protect the nonbleeding lung from blood aspiration (52). However, misplacement of double-lumen tubes is a serious problem. In one series of 172 patients, misplacement was detected by fiberoptic bronchoscope in 74 patients (45%) after initial placement and in 93 patients (54%) after patient positioning (53). Protection of the nonbleeding lung from blood spill can also be achieved by intubation of the respective main bronchus with a single-lumen endotracheal tube. These selective intubation techniques are only palliative and should be done with the prospect of a surgical intervention (37).

Bronchial Artery Embolization. Bronchial artery embolization (BAE), first performed by Remy et al. in 1973 (54), is now considered the most effective non-surgical treatment in massive hemoptysis because of immediate and long-term results. In a large study of 209 patients, the success rate within 24 hrs was 98%; however, 16% of the patients had recurrent bleeding within a 1-yr follow-up period (55). Selective angiography should be performed initially to locate the bleeding bronchial artery before the injection of particles (polyvinyl alcohol foam, isobutyl-2-cyanoacrylate, absorbable gelatin pledgets, or Gianturco steel coils). Failure of BAE is mainly attributable to non-bronchial collateral arteries branching from the phrenic, intercostal, mammary, and subclavian arteries (56). The most serious complication of BAE is the accidental embolization of the spinal artery either by contrast material or the embolizing particles causing ischemic injury to the spinal cord. The reported prevalence is extremely low (<1%) and it occurs when the spinal artery arises from the bronchial artery (57).

Conservative Management. Invasive therapeutic measures are not indicated in the control of hemoptysis caused by anticoagulant therapy, blood dyscrasia, or Goodpasture's syndrome. These conditions can be treated by appropriate medical therapy (2, 25).

The overall mortality rate attributed to massive hemoptysis is largely influenced by malignant etiologies and by the bleeding rate. In one study of 59 patients with hemoptysis, the mortality rate was 59% in patients with malignancy and 58% in patients with bleeding >1000 mL/24 hrs, but it was only 9% if the bleeding was <1000 mL/24 hrs (2).

The coexistence of hemoptysis over 1000 mL/24 hrs and malignancy in the same patient brought the mortality rate to 80%. Furthermore, a more conservative approach has been advocated for certain conditions like bronchiectasis, acute necrotizing pulmonary infections, or abscess, in which the mortality rate is very low (<1%) (2, 58). A general guideline for the management of massive hemoptysis is summarized in Figure 1.

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ATTENTION

See the Society of Critical Care Medicine's "FORUM 2" with all the latest news. Look for the yellow pages in this issue.

Key Words: computed tomography; endobronchial tamponade; bronchial artery embolization; acid-fast bacillus; potassium hydroxide; intensive care unit; complete blood count; blood urea nitrogen; arterial blood gas

IMAGE GALLERY

Select All

 Export Selected to PowerPoint

Neoplasm:
1) bronchial carcinoma, adenoma
2) metastatic lung cancer
Bronchiectasis
Infections:
1) mycobacteria, especially tuberculosis
2) fungal infections
3) lung abscess, necrotizing pneumonia
4) paragonimiasis
5) hydatid cyst
Vascular:
1) pulmonary infarct, embolism
2) mitral stenosis
3) iatrogenic rupture of pulmonary artery by balloon-tipped catheter
4) broncho-arterial fistula
5) ruptured thoracic aneurysm
6) arteriovenous malformation
Vasculitis:
1) Behcet's disease
2) Wegener's granulomatosis
Miscellaneous:
anticoagulant therapy, coagulopathies (von Willebrand's disease, hemophilia, thrombocytopenia), Goodpasture's syndrome, trauma, lymphangioleiomyomatosis



☐ Figure 1

☐ Table 1

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Hemoptysis

Take Home Points:

1. Most hemoptysis is not massive, but true massive hemoptysis is a medical emergency. Patients die from asphyxiation or exsanguination.
2. The top 3 causes of massive hemoptysis are TB, bronchiectasis, and carcinoma. The mnemonic "BATTLE CAMP" may help you remember others.
3. Remember the 3 principles of management: 1) maintain airway patency and oxygenation, 2) localize the source of bleeding, 3) control hemorrhage.

Overview

- Definition of massive hemoptysis is unclear: criteria range from 100cc q day to 1000cc over a few days, and patient quantitation of blood loss is typically inaccurate.
- Massive hemoptysis can be fatal, with deaths occurring by exsanguination or asphyxiation from flooding of the alveoli with blood and intractable hypoxemia.
- Risk of death correlates strongly with amount of blood expectorated, rate of bleeding, amount of blood within the lungs, and underlying pulmonary reserve.
- Fewer than 5% of patients with hemoptysis expectorate large volumes of blood, but those who do have acutely fatal bleeds between 7 and 32% of the time.

Vascular Anatomy

- The pulmonary circulation carries deoxygenated blood from the right ventricle across the pulmonary capillary bed and returns oxygenated blood via the pulmonary veins. This is a low pressure circuit with normal pressures of 15-20/5-10 mmHg.
- The bronchial circulation is a nutritional source for the structural elements of the lung. Bronchial arteries branch from the aorta and are at systemic pressure. They can bleed profusely when airways are diseased.

Etiologies of Hemoptysis

"BATTLE CAMP": Bronchitis, bronchiectasis, aspergilloma, tumor, tuberculosis, lung abscess, emboli, coagulopathy, autoimmune disorders, AVM, alveolar hemorrhage, mitral stenosis, pneumonia

- Tuberculosis may cause hemoptysis either in active disease (cavitary lesions, rupture of pulmonary artery aneurysms) or as late sequelae (rupture of aneurysms or secondary to bronchiectasis). Rupture of Rasmussen's aneurysm can occur with active disease or as a late finding. It occurs when there is rupture of ectatic portions of the pulmonary arteries traversing thick-walled cavities.
- Bronchiectasis is due to destruction of the cartilaginous support of the bronchial wall by infection or bronchial dilatation owing to parenchymal retraction from alveolar fibrosis. This causes bronchial artery hypertrophy and augmentation of anastomoses with the pulmonary artery bed.
- Fungal infection (mycetomas) forms in patients with preexisting cavitary disease.
- Lung abscess causes hemoptysis, probably because of necrotizing effects of the primary infection on lung parenchyma and vasculature.
- Mitral Stenosis or congenital heart disease cause hemoptysis via pulmonary hypertension, which lead to varices in the submucosa of the bronchial walls.
- Carcinoma 7-10% of patients with bronchogenic carcinoma present with blood streaked sputum; massive hemoptysis is rare. Vast majority of primary lung cancers associated with hemoptysis are squamous in origin. In metastatic lung disease, hemoptysis is most often attributable to endobronchial lesions. Among patients with hematologic malignancies, hemoptysis is most often secondary to fungal infection.
- Iatrogenic hemoptysis results from bronch., transthoracic needle bx or PA cath. use.
- Autoimmune disorders accounts for a spectrum of disease, most related to vasculitides (ie Behcet's, PAN, SLE)

Management (3 principles)

- Maintain of airway patency. Asphyxiation is the most frequent complication of massive hemoptysis. Obtain urgent **CXR** and **ABG** to assess the status of oxygenation and the amount of blood in the lung. If emergent intubation needed, use a **8mm catheter or larger** (so that bronchoscopy can be performed). Monitor pts in the **ICU**. If bleeding site is known, place pt. in the **lateral decubitus position** with the affected lung in the dependent position. Obtain good venous access.
- Routine lab data includes **CBC, BUN/CR, PT/PTT and U/A**.
- Localize the source of the bleeding. If there is any doubt, the **source of the bleeding (pulmonary vs GI vs ENT)** should be ascertained. **Hematemesis** tends to be **darker** (hemoptysis is bright red). In addition, **hemoptysis** will be **alkaline**, whereas **hematemesis** is usually **acidic**. If needed, indirect visualization of the pharynx and larynx can be done to determine an ENT source.
- In general, **early bronchoscopy** is the procedure of choice. **Flexible bronch.** should be performed on patients (who **should be intubated** prior to this). If bleeding is so rapid to make visualization difficult, then **rigid bronch.** can be used (**more effective** suction). If bronchoscopy is unsuccessful, **angiography** can be performed.
- Control the hemorrhage. Correct **coagulopathy**. **Bronchoscopic** techniques include: **irrigation with cold saline, topical administration of vasoconstrictive agents, endobronchial tamponade, and unilateral lung ventilation**. If bleeding is **severe**, place a **double lumen endotracheal tube** (permits ventilation of both lungs, while preventing aspiration from one lung to another).
- **Pulmonary angiography and embolization** is an increasingly popular method of controlling bleeding, and has replaced the need for emergent surgery in many patients. Used principally for bleeds involving **high pressure bronchial** circulation (accounts for most cases of massive hemoptysis anyway). If bleeding persists after bronchial and collateral systemic arteriography, the pulmonary arteries should be examined. Alveolar hemorrhage, particularly in **autoimmune** diseases, may need **high steroid** doses for management.
- **Consider surgery** for lateralized uncontrollable massive hemoptysis unresponsive to other measures or as a definitive therapy in patients whose hemoptysis and general medical condition have stabilized.

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REVIEW SERIES

The pulmonary physician in critical care • Illustrative case 7: Assessment and management of massive haemoptysis

J L Lordan, A Gascoigne, P A Corris

Thorax 2003;58:814–819

The unpredictable and potentially lethal course of massive haemoptysis requires prompt resuscitation, airway protection, and correction of coagulopathy. Early investigation with bronchoscopy is recommended for localisation and control of bleeding by the application of topical adrenaline, balloon tamponade, or selective lung intubation. There is increasing acceptance of bronchial artery embolisation as the treatment of choice for acute massive haemoptysis not controlled by conservative treatment, when a bronchial artery can be identified as the source of bleeding. Surgical resection remains the treatment of choice for particular conditions where the bleeding site is localised and the patient is fit for lung resection.

diameter, fig 2). The internal mammary artery was also catheterised and a pathological circulation was noted that was occluded using platinum coils (fig 1A) and PVA granules, with no complications and no recurrence of haemoptysis.

DEFINITION

Although there is no generally accepted definition of the volume of blood that constitutes a massive haemoptysis, studies have quoted volumes ranging from 100 ml up to or more than 1000 ml per day.² As the anatomical dead space of the major airways is 100–200 ml, a more relevant definition of massive haemoptysis is the volume that is life threatening by virtue of airway obstruction or blood loss.^{5,6}

AETIOLOGY

It is important to establish that the lung is the source of bleeding, in part by excluding the nasopharynx or gastrointestinal tract. The most common causes of massive haemoptysis are listed in box 1. Haemoptysis originates from the bronchial and pulmonary circulation in 90% and 5% of cases, respectively.⁷ Bleeding from the bronchial arteries has the propensity to cause massive haemoptysis as it is a circulation at systemic pressure. Alveolar haemorrhage is a recognised cause of haemoptysis, but rarely causes massive bleeding as the alveoli have the capacity to accommodate a large volume of blood.⁸ A more common presentation is mild haemoptysis, pulmonary infiltrates, and anaemia.²

Chronic inflammatory conditions (including bronchiectasis, tuberculosis, lung abscess) and lung malignancies are the most common causes of massive haemoptysis.^{9,10} Similarly, bleeding may occur from a mycetoma in the presence of cavitating lung disease.^{11,12} The concurrent development of haemoptysis and menstruation points to a diagnosis of catamenial haemoptysis. The presence of haemoptysis and spontaneous pneumothorax in a woman of childbearing age with diffuse interstitial abnormalities on the chest radiograph should raise the suspicion of lymphangioleiomyomatosis.¹⁶

The presence of a saddle nose, rhinitis, or perforated nasal septum may suggest a diagnosis of Wegener's granulomatosis.¹⁷ Features of Behçet's disease include oral or genital ulceration, uveitis, cutaneous nodules, and pulmonary artery aneurysm which is associated with a 30% 2 year mortality rate.¹⁸ Although haematuria may be

Haemoptysis may be the presenting symptom of a number of diseases,^{1,2} with an associated mortality ranging from 7% to 30%.^{3–5} Although fewer than 5% of patients presenting with haemoptysis expectorate large volumes of blood, the explosive clinical presentation and the unpredictable course of life threatening haemoptysis demands prompt evaluation and management. We have reviewed the aetiology of massive haemoptysis and alveolar haemorrhage, with particular reference to current diagnostic and therapeutic strategies.

CASE HISTORY

A 69 year old woman was an emergency admission with large volume haemoptysis which did not settle spontaneously. She had previously undergone a left mastectomy for breast carcinoma. Alveolar shadowing was noted in the left mid zone on the chest radiograph, consistent with recent pulmonary haemorrhage (fig 1A). A thoracic computed tomographic (CT) scan confirmed consolidation and volume loss in the left upper lobe and lingula, but also showed a mass anteriorly eroding through the chest wall, consistent with local recurrence of the breast neoplasm (fig 1B). Pulmonary angiography showed no abnormality, but bronchial angiography identified a trunk that supplied a moderate pathological circulation anteriorly in the left upper lobe in the region of the abnormality on the CT scan. The artery was successfully embolised using polyvinyl alcohol (PVA) foam granules (500–700 µm in

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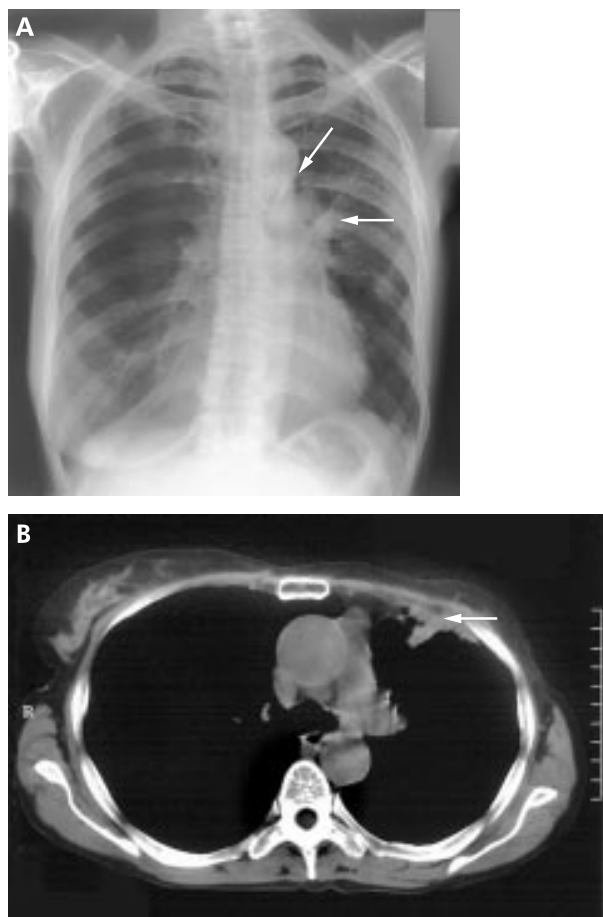


Figure 1 (A) Chest radiograph showing previous left mastectomy and left upper lobe and lingular infiltrates due to airway bleeding. A platinum embolisation coil is noted on this post-embolisation radiograph (arrow). (B) CT scan showing a mass lesion (arrow) involving the left anterior chest wall with associated left upper zone consolidation, consistent with recent haemoptysis and local tumour recurrence following the previous mastectomy.

present in association with Goodpasture's disease, 5–10% of patients present without clinical evidence of renal disease.⁸

DIAGNOSTIC PROCEDURES

Sputum should be sent for microbiological investigation, including staining and culture for mycobacteria, and cytological examination if the patient is a smoker and over 40 years of age. Chest radiography may help to identify causative lesions or infiltrates resulting from pulmonary haemorrhage, but fails to localise the lesion in 20–46% of patients with haemoptysis.¹⁹ A CT scan may show small bronchial carcinomas or localised bronchiectasis.^{13 20 21} The use of contrast may help to identify vascular abnormalities such as arteriovenous malformations or aneurysms.^{14 22} Despite all investigative procedures, the aetiology of haemoptysis is unknown in up to 5–10% of patients.⁷

MANAGEMENT OF MASSIVE HAEMOPTYSIS

The initial approach to managing life threatening haemorrhage involves resuscitation and protecting the airway (fig 3), the second step is directed at localising the site and cause of bleeding, and the final step involves the application of definitive and specific treatments to prevent recurrent bleeding.

Airway protection and resuscitation

All patients with massive haemoptysis should be monitored in an intensive care unit (ICU) or high dependency unit (HDU) and the patient's fitness for surgery established. Attempts should be made to determine the side of bleeding and the patient positioned with the bleeding side down to prevent aspiration into the unaffected lung. Blood loss should be treated with volume resuscitation, blood transfusion, and correction of coagulopathy. If large volume bleeding continues or the airway is compromised, the patient's trachea should be intubated with as large an endotracheal tube as is possible to allow adequate suctioning and access for bronchoscopy.² If the bleeding can only be localised to the right or left lung, unilateral lung intubation may protect the non-bleeding lung.²³ For right sided bleeding a bronchoscope may be directed into the left main bronchus which can then be selectively intubated over the bronchoscope with the patient lying in the right lateral position (fig 4). The left lung is then protected from aspiration and selectively ventilated. For a left sided bleeding

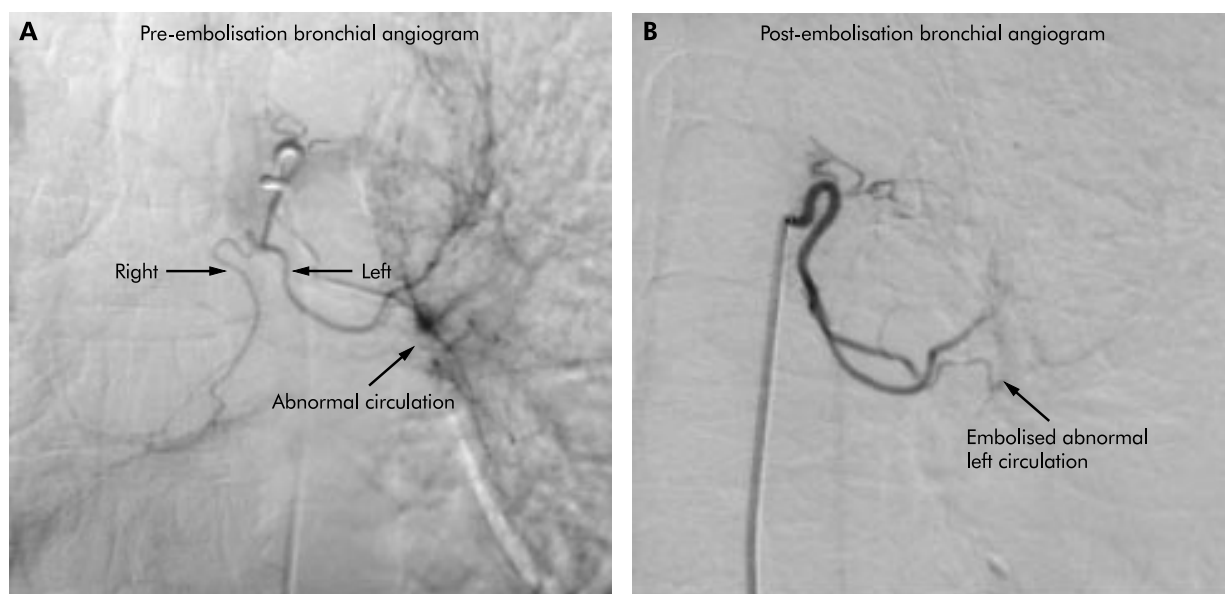


Figure 2 Use of selective bronchial artery embolisation to control massive haemoptysis. (A) Bronchial angiogram showing common trunk and left sided abnormal circulation pre-embolisation, and (B) post-embolisation angiogram showing the left bronchial artery and successful embolisation of abnormal vessels.

Box 1 Causes of massive haemoptysis and alveolar haemorrhage**Infections**

- Mycobacteria, particularly tuberculosis
- Fungal infections (mycetoma)
- Lung abscess
- Necrotising pneumonia (*Klebsiella*, *Staphylococcus*, *Legionella*)

Iatrogenic

- Swan-Ganz catheterisation
- Bronchoscopy
- Transbronchial biopsy
- Transtracheal aspirate

Parasitic

- Hydatid cyst
- Paragonimiasis

Trauma

- Blunt/penetrating injury
- Suction ulcers
- Tracheoarterial fistula

Neoplasm

- Bronchogenic carcinoma
- Bronchial adenoma
- Pulmonary metastases
- Sarcoma

Haemoptysis in children

- Bronchial adenoma
- Foreign body aspiration
- Vascular anomalies

Vascular

- Pulmonary infarct, embolism
- Mitral stenosis
- Arteriobronchial fistula
- Arteriovenous malformations
- Bronchial telangiectasia
- Left ventricular failure

Coagulopathy

- Von Willebrand's disease
- Haemophilia
- Anticoagulant therapy
- Thrombocytopenia
- Platelet dysfunction
- Disseminated intravascular coagulation

Vasculitis

- Behcet's disease
- Wegener's granulomatosis

Pulmonary

- Bronchiectasis (including cystic fibrosis)
- Chronic bronchitis
- Emphysematous bullae

Miscellaneous

- Lymphangioliomatosis
- Catamenial (endometriosis)
- Pneumoconiosis
- Broncholith
- Idiopathic

Spurious

- Epistaxis
- Haematemesis

source the patient is placed in the left lateral position and selective intubation of the right lung may be performed, but this may lead to occlusion of the right upper lobe bronchus.² An alternative strategy is to pass an endotracheal tube over the bronchoscope into the trachea. A Fogarty catheter (size 14 French/100 cm length) may then be passed through the vocal cords beside the endotracheal tube, directed by the bronchoscope into the left main bronchus and inflated (fig 5). This prevents aspiration of blood from the left lung and the endotracheal tube positioned in the trachea allows ventilation of the unaffected right lung.

An alternative strategy for unilateral bleeding is to pass a double lumen endotracheal tube, which allows isolation and ventilation of the normal lung and prevents aspiration from the side involved by bleeding (fig 6).² However, inserting double lumen tubes should only be performed by experienced operators to avoid the serious consequences of poor positioning.²⁴

Identifying the site and cause of bleeding

Precise localisation of the bleeding site directs definitive treatment. Fiberoptic bronchoscopy and angiography are the modalities of choice to localise the site of bleeding and to allow therapeutic intervention, although the timing of bronchoscopy is controversial.^{25–26} Early compared with delayed bronchoscopy gives a higher yield for localising the site of bleeding.²⁶ In contrast to mild haemoptysis, localisation of the site of bleeding is essential in the management of massive haemoptysis and urgent bronchoscopy should be considered.⁷

Fiberoptic bronchoscopy can be performed at the bedside and allows visualisation of more peripheral and upper lobe lesions, but has a limited suction capacity.^{25–26} Rigid bronchoscopy provides superior suction to maintain airway patency, but it has a limited ability to identify peripheral lesions and does not permit good views of the upper lobes.⁷ It is usually performed under general anaesthetic but can be performed under local anaesthesia and sedation in experienced hands.²⁷ The techniques can be combined when the fiberoptic bronchoscope is passed through the lumen of the rigid bronchoscope.

Bronchoscopic treatment

Instillation of epinephrine (1:20 000) is advocated to control bleeding, although its efficacy in life threatening haemoptysis is uncertain.² The topical application of thrombin and thrombin-fibrinogen solutions has also had some success, but further study is required before widespread use can be recommended.²⁸

In massive haemoptysis, isolation of a bleeding segment with a balloon catheter may prevent aspiration of blood into the large airways, thereby maintaining airway patency and oxygenation. Having identified the segmental bronchus that is the source of bleeding, the bronchoscope is wedged in the orifice. A size 4–7 Fr 200 cm balloon catheter is passed through the working channel of the bronchoscope and the balloon is inflated in the affected segment, isolating the bleeding site (fig 7).² A double lumen balloon catheter (6 Fr, 170 cm long) with a detachable valve at the proximal end has recently been designed that passes through the bronchoscope channel and allows the removal of the bronchoscope without any modification of the catheter.²⁹ The second channel of the catheter may also be used to instil vasoactive drugs to help control bleeding. The bronchoscope can then be removed over the catheter, which is left in place for 24 hours. The balloon may be deflated under controlled conditions with bronchoscopic visualisation and the catheter removed if the bleeding has stopped. The prolonged use of balloon tamponade catheters should be avoided to prevent ischaemic mucosal injury and post-obstructive pneumonia. Endobronchial tamponade should only be applied as a temporary measure until a more definitive therapeutic procedure can be deployed.

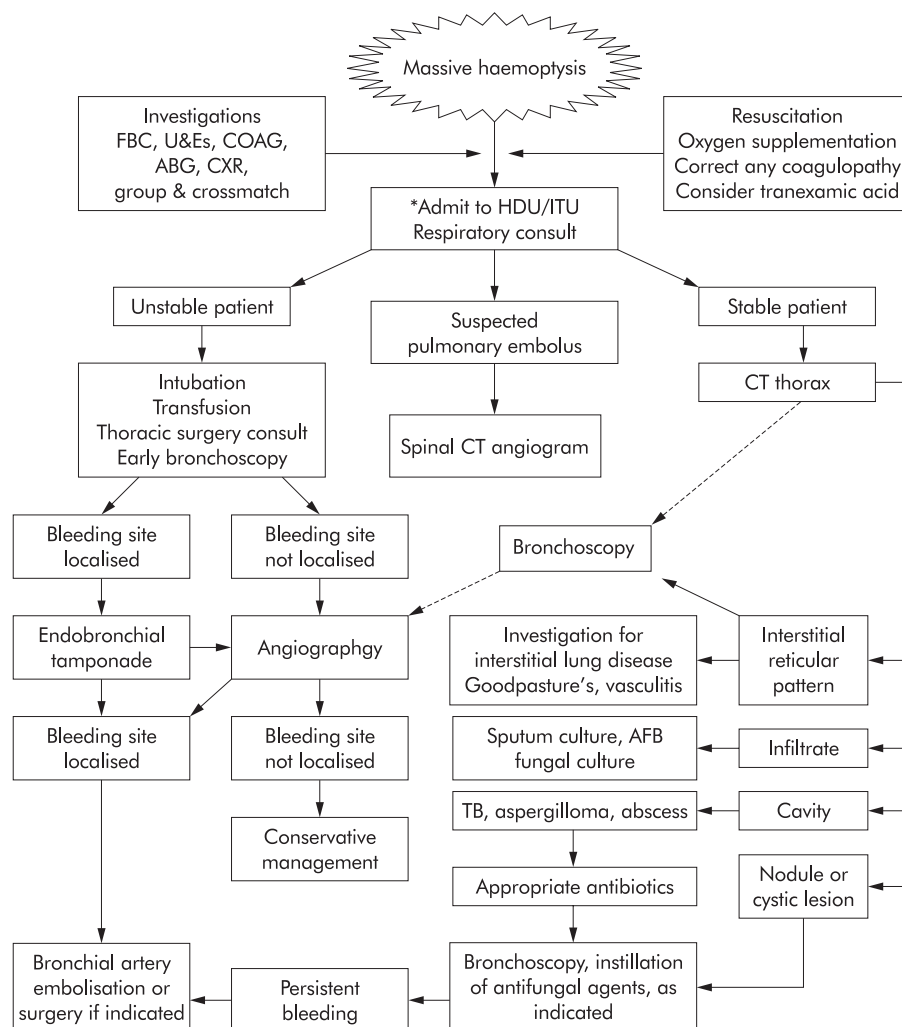


Figure 3 Algorithm for management of massive haemoptysis. *Palliative measures may be appropriate in the setting of advanced malignancy.

Neodymium-yttrium-aluminium-garnet (Nd-YAG) laser photocoagulation has been used with some success in the management of massive haemorrhage associated with directly visualised endobronchial lesions.³⁰ However, targeting the cul-

prit vessel with the laser beam can be difficult in the presence of ongoing bleeding.

Bronchial artery embolisation (BAE)

This was first reported by Remy and colleagues in 1973³¹ and is increasingly used in the management of life threatening

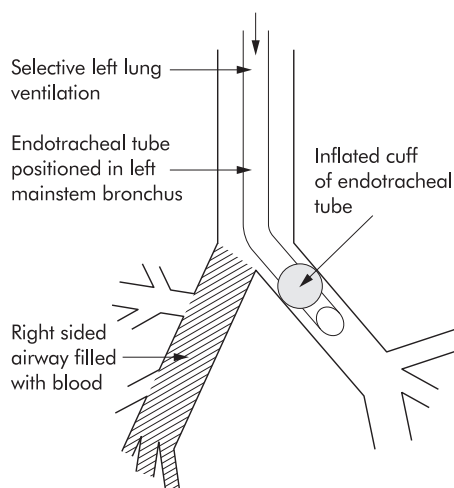


Figure 4 Selective intubation of left main bronchus in a case of right sided massive haemoptysis.

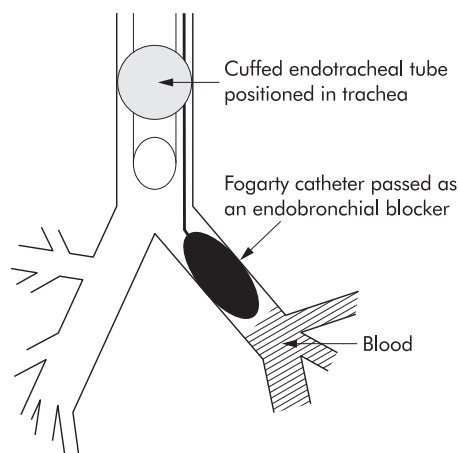


Figure 5 Control of left sided massive haemoptysis by tracheal intubation, placement, and inflation of a Fogarty catheter in the left main bronchus.

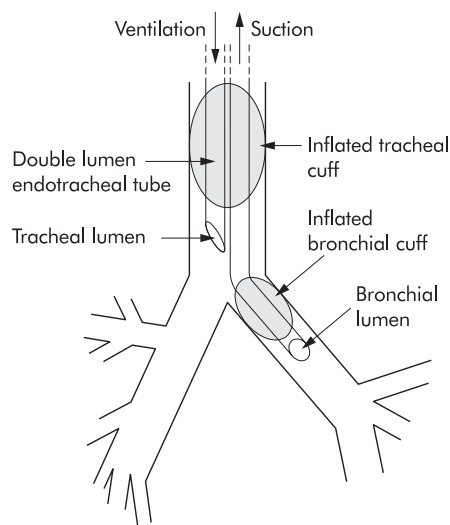


Figure 6 Application of a double lumen endotracheal tube for the control of massive haemorrhage. The bronchial lumen is positioned in the left main bronchus to ventilate the left lung and the tracheal lumen is positioned above the carina, allowing ventilation of the right lung while preventing occlusion of the right upper lobe orifice.

haemoptysis.²⁰ The procedure involves the initial identification of the bleeding vessel by **selective bronchial artery cannulation**, and the subsequent injection of particles (polyvinyl alcohol foam, isobutyl-2-cyanoacrylate, Gianturco steel coils or absorbable gelatin pledgets) into the feeding vessel (fig 2). A number of features provide clues to the bronchial artery as the source of bleeding, including the infrequent identification of **extravasated dye** or the visualisation of **tortuous vessels** of increased calibre or aneurysmal dilatation.³² The immediate **success rates** for control of massive haemoptysis is excellent, ranging from **64% to 100%**, although recurrent non-massive bleeding has been reported in 16–46% of patients.^{32–35} **Technical failure** of BAE occurs in up to **13%** of cases and is largely caused by non-bronchial artery **collaterals** from systemic vessels such as the **phrenic, intercostal, mammary, or subclavian arteries**.³⁵ Complications of BAE include vessel perforation, intimal tears, chest pain, pyrexia, haemoptysis, systemic embolisation, and neurological complications. When the **anterior spinal artery** is identified as **originating** from the **bronchial artery**, embolisation is often deferred owing to the

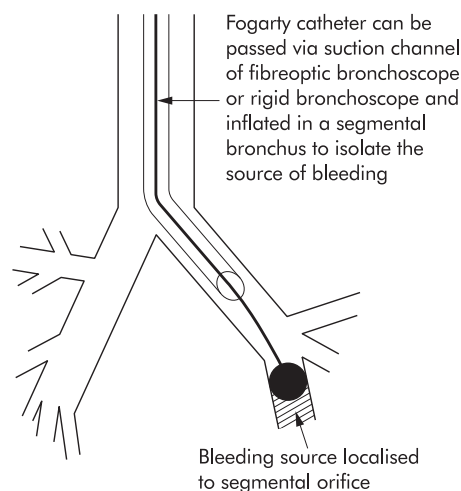


Figure 7 Placement of a Fogarty catheter guided by fiberoptic bronchoscopy to control massive bleeding from a segmental bronchus.

risk of infarction and paraparesis.³² The development and application of coaxial microcatheter systems allows more selective catheterisation and embolisation of branches of the bronchial arteries, thereby reducing the risk of occluding branches such as the anterior spinal artery.³⁴

Surgical management

Surgery is considered for the management of localised lesions. **Surgical mortality ranges from 1% to 50%** in different series depending on selection criteria, but bias in the selection of candidates for surgery limits a direct comparison with medical treatment.² Surgery is contraindicated in patients with inadequate respiratory reserve or those with inoperable lung cancer due to direct thoracic spread. Surgical resection is indicated when BAE is unavailable or the bleeding is unlikely to be controlled by embolisation. It remains the treatment of choice for the management of life threatening haemoptysis due to a leaking aortic aneurysm, selected cases of arteriovenous malformations, hydatid cyst, iatrogenic pulmonary rupture, chest injuries, bronchial adenoma, or haemoptysis related to mycetoma resistant to other treatments.^{7, 23} **Pulmonary artery rupture related to the use of pulmonary artery catheters may be temporarily controlled by withdrawing the catheter slightly and reinflating the balloon to compress the bleeding vessel more proximally.**³⁶ However, **surgical resection** of the bleeding vessel is the **definitive** management.

The onset of massive haemoptysis in a patient with a **tracheostomy** may be associated with the development of a **tracheal-arterial fistula, usually the innominate artery.**³⁷ The prompt application of **anterior and downward pressure** on the **tracheal cannula** and **overinflation** of the **tracheostomy balloon** may help to tamponade the bleeding vessel, and immediate **surgical** review should be requested. Deflation of the tracheostomy balloon and removal of the tracheal cannula should be performed in a controlled environment.

Other treatment

The **oral antifibrinolytic agent tranexamic acid**, an inhibitor of plasminogen activation, is frequently used to control recurrent haemoptysis. Intravenous vasopressin has also been used but caution is advised in patients with coexistent coronary artery disease or hypertension. Vasoconstriction of the bronchial artery may also hamper effective BAE by obscuring the site of bleeding, leading to difficulties in cannulation of the artery.²

Systemic antifungal agents have been tried in the management of haemoptysis related to mycetoma, but the results have been **poor**. By contrast, the **direct instillation** of **antifungal** drugs such as amphotericin B with or without N-acetylcysteine or iodine by means of a percutaneous or transbronchial catheter in the cavity has resulted in satisfactory control of haemoptysis in some cases.^{12, 38} This technique should be considered in patients with ongoing bleeding following attempted BAE who are not otherwise fit for surgical resection.

Invasive therapeutic procedures have **no role** in the management of pulmonary haemorrhage related to **coagulopathy**, blood dyscrasias, or immunologically mediated alveolar haemorrhage. Appropriate **medical treatment** is usually sufficient.³⁹ On the rare occasion when an immunologically mediated alveolar haemorrhage leads to massive haemoptysis, the administration of systemic corticosteroids, cytotoxic agents, or plasmapheresis may be useful.⁸ The long term administration of danazol or gonadotrophin releasing hormone agonists may prove useful in the management of catamenial haemoptysis.⁴⁰ Radiation therapy has been used in the management of massive haemoptysis associated with vascular tumours or mycetoma by inducing necrosis of feeding blood vessels and vascular thrombosis due to perivascular oedema.⁴¹

OUTCOME

Mortality has been closely correlated with the volume of blood expectorated, the rate of bleeding, the amount of blood retained within the lungs and premonitory respiratory reserve, independent of the aetiology of bleeding.¹⁻⁴ The mortality rate is 58% when the rate of blood loss exceeds 1000 ml/24 hours, compared with 9% if bleeding is less than 1000 ml/hour.^{7,39} The mortality rate in patients with malignancy is 59%, which increases to 80% in the presence of a combination of malignant aetiology and a bleeding rate of more than 1000 ml/24 hours. A better outcome has been noted for massive haemorrhage due to bronchiectasis, lung abscess, or necrotising pulmonary infections, with a mortality rate of less than 1% in some series.³⁹

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