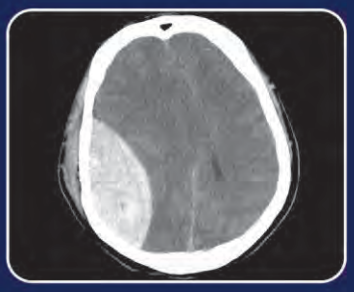
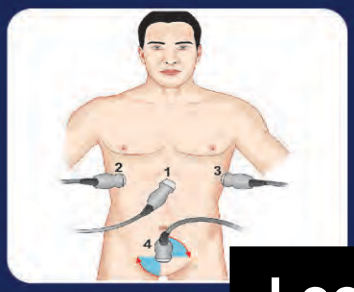
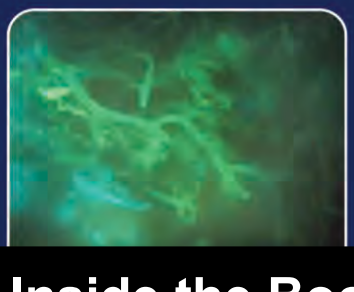
Textbook of CRITICAL CARE

Including Trauma and Emergency Care







Editor-in-Chief
Yatin Mehta

Editors
Jeetendra Sharma
Chitra Mehta

Forewords
Dr Jean-Louis Vincent
Dr Harsh Vardhan

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JAYPEE

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CHAPTER

Massive Hemoptysis

Chitra Mehta, Yatin Mehta

INTRODUCTION

Massive hemoptysis is probably the most catastrophic and challenging condition faced by critical care specialists world over. Ideally every hemoptysis should be regarded as potentially life threatening. Because of its unpredictable nature, it requires appropriate anticipation, thorough investigation and timely intervention. Efforts should however be made to distinguish it from pseudohemoptysis such as hematemesis or bleed from upper respiratory tract.

DEFINITION

There is no universally accepted single definition of massive hemoptysis. Various studies have mentioned critical volume ranging from 100 mL to >1,000 mL in 24 hours. Most commonly used criteria is 400–600 mL of blood per day. It is more relevant to define massive hemoptysis in terms of bleeding associated with life-threatening situations such as asphyxiation or airway obstruction.

EPIDEMIOLOGY

- Massive hemoptysis accounts for <5% of all cases of hemoptysis.
- Tuberculosis is the most common cause of hemoptysis worldwide but its propensity for massive hemoptysis is less. Chronic inflammatory nontuberculous lung diseases and carcinomas are the leading causes of massive hemoptysis in western countries. In developing countries, it is still tuberculosis related sequlae such as bronchiectasis, Rasmussen's aneurysm which are mainly responsible for massive hemoptysis.
- Mortality due to massive hemoptysis is dependent on the severity of bleeding and rate of blood loss.[1] This can be seen in **Table 1**.
- Rebleeds have been found to have mortality rate as high as 45% if definitive therapy has not been instituted.
- Mortality is found to be higher if hemorrhage is unexpected, in emergent versus elective surgery and if there is an underlying neoplastic lesion.
- Mortality rate associated with conservative management is potentially high therefore all treatment modalities should be explored for patients with localized pathology.

TABLE 1: Hemoptysis and mortality.

Hemoptysis	*Mortality*
Hemoptysis of <1,000 mL in 24 hours	9%
Hemoptysis of >1,000 mL in 24 hours	58%
Rate of >600 mL in 4 hours	71%
Rate of 600 mL in 4–16 hours	45%
Rate of 600 mL in 16–48 hours	5%

- Since the cause of death is asphyxiation and not blood loss, lot depends on the rate of bleeding and condition of underlying lung.[1]

ANATOMY OF THE PULMONARY CIRCULATION

The lung has a unique feature that it receives a dual blood supply, i.e., from pulmonary and bronchial circulations.

Pulmonary circulation accounts for 99% of the blood supply to lungs but it is primarily involved in gas exchange process. It is basically a low pressure, low resistance system that has the capacity to accommodate significant increases in blood flow with little change in pressures. Pulmonary artery pressure may however increase in certain pulmonary parenchymal and pulmonary vascular diseases. The pulmonary circulation accounts for <10% of cases of massive hemoptysis.[2,3]

Bronchial Circulation

Bronchial arteries originate from either aorta or intercostal arteries. These basically supply nutrients to the pulmonary parenchyma. Bronchial circulation is a high-pressure system, and is most prone to give rise to massive hemoptysis. It forms anastomosis in the peribronchial space and gives rise to small penetrating arteries, which supply the bronchial mucosa.

Nonbronchial System Collateral Circulation

Nonbronchial collaterals usually arise as a part of neovascularization of the lung parenchyma in inflammatory lung diseases. They usually arise from the internal mammary, carotid, coronary, and thyrocervical arteries. This circulation might be responsible for bleeds in certain cases of massive hemoptysis. This fact is highlighted by recurrence of hemoptysis despite

bronchial-artery embolization (BAE), absence of bronchial arterial supply to an area of lung parenchyma on initial bronchial arteriography and presence of pleural disease.

Pulmonary Venous Abnormalities

Pulmonary veins may be responsible for bleeds in cardiac diseases such as mitral stenosis (MS) or mitral regurgitation (MR).

ETIOLOGY

There are multiple causes of hemoptysis but certain conditions have a higher predilection for massive hemoptysis.[4] The most common causes of massive hemoptysis are listed in **Table 2**. It is however imperative to differentiate it from bleeding from a gastrointestinal or nasopharyngeal source.

PATHOPHYSIOLOGY[5,6]

Inflammatory Lung Diseases

Chronic inflammatory conditions are leading causes of massive hemoptysis. The most common conditions are chronic bronchitis, bronchietasis, necrotizing pneumonia, lung abscess, aspergillosis, and tuberculosis.

TABLE 2: Causes of massive hemoptysis.

Infection	• Bronchiectasis • Tuberculosis, active or cavitary • Invasive mycetoma (aspergillosis and mucormycosis) • Pneumonia/bronchiolitis • Lung abscess • Hydatid cyst • Cystic fibrosis
Neoplasm	• Lung cancer (small/nonsmall) • Pulmonary carcinoid • Endobronchial metastasis • Pulmonary metastasis
Cardiac/ vascular	• Arteriovenous malformation • Mitral stenosis • Pulmonary infarction/embolism • Congenital heart defects • Pulmonary hypertension • Aortic aneurysm • Bronchoarterial fistula • Congestive heart failure • Septic embolism
Iatrogenic	• Bronchoscopy • Transthoracic needle aspiration • Pulmonary artery catheterization • Tracheoinnominate fistula
Trauma	• Blunt chest trauma • Penetrating chest trauma
Radiotherapy	• Directed chemotherapeutic agents (e.g., bevacizumab)
Miscellaneous	• Pulmonary renal syndromes (Wegener's granulamatosis, Goodpasture's syndrome) • Immunologic lung diseases • Coagulopathies • Bone marrow transplantation • Anticoagulant therapy

Bronchiectasis and Cystic Fibrosis

Due to recurrent infections in bronchiectasis, there is proliferation and enlargement of bronchial arteries with formation of ectatic submucosal arteries. Degeneration of wall of these vessels causes spontaneous rupture resulting in hemoptysis.

Infections

Prior to introduction of antitubercular therapy, tuberculosis was the leading cause of massive hemoptysis worldwide. This was secondary to mechanisms such as Rasmussen's aneurysm, residual bronchiectasis, erosion of a bronchiole and acute cavitary diseases. In recent times, these however account for massive hemoptysis in developing world mostly. Fungal infection has become more common cause of massive hemoptysis particularly in immune compromised patients, and in those with pre-existing cavitary lung diseases. Fungal infection causes destruction of tissues and vessels usually by colonizing previous area of destroyed pulmonary parenchyma. The intracavity fungal ball induces neoangiogenesis with vessels usually arising from bronchial circulation. These are part of the high-pressure system. Other pulmonary infections are also associated with massive hemoptysis such as pneumonias caused due to *Staphylococcus* species, *Klebsiella pneumoniae* or *Legionella pneumoniae*.

Neoplasms

Bronchogenic carcinomas result in hemoptysis quite frequently, though massive hemoptysis is rare. It is most commonly associated with squamous cell carcinoma. Endobronchial location or cavitation have higher predilection for hemoptysis. In addition to bronchogenic carcinoma, any endobronchial or intraparenchymal metastatic tumor of lung can result in massive hemoptysis. It can also result from interventions used to treat lung malignancy such as endobronchial brachytherapy or radiofrequency ablation of lung neoplasms.

Cardiovascular Diseases

Hemoptysis does not occur from the heart failure itself. Most commonly, it is due to mitral valve diseases such as MS or MR. Elevated pulmonary venous pressure leads to varices formation, which rupture and result in massive hemoptysis.

Pulmonary Embolism

Hemoptysis associated with pulmonary embolism (PE) is usually mild but can reach massive proportions if there is a bronchial arterial anastomosis into the infarcted segment of the lung.

Trauma

Massive hemoptysis can be present in patients with chest trauma. This is usually secondary to decelerating injury to pulmonary or bronchial vasculature. Penetrating chest trauma can directly injure the major vascular structure of the thorax and cause massive hemoptysis. Fractured ribs and flail segments can directly cause lung contusion with hemoptysis, hemothorax or both.

Iatrogenic Causes

Pulmonary Artery Catheterization

Perforation of the pulmonary artery secondary to distal migration of the catheter tip, and, over inflation of a balloon

during pulmonary artery catheterization can result in massive hemoptysis; other risk factors for pulmonary artery rupture are concomitant anticoagulation, cardiopulmonary bypass, hypothermia, advanced age, and pulmonary hypertension.

Bronchoscopy

Massive hemoptysis during bronchoscopy is usually rare. It can occur if there is coagulopathy during endobronchial biopsy of carcinoid tumors, and transbronchial lung biopsy.

Tracheostomy

A tracheoinnominate artery fistula (TIF) is a known complication in chronic tracheostomy patients. It usually occurs in the presence of low tracheal insertion site or presence of a high innominate artery, resulting in tracheal wall erosion and secondary TIF formation.

CLINICAL APPROACH

Clinicians are faced with many dilemmas in dealing with massive hemoptysis. First priority is the emergency management of massive or exsanguinating hemoptysis in terms of airway control and lung protection. Second step is to accurately identify patients with sentinel bleed, which may presage a second more massive bleed. In clinical practice it is very difficult to identify this group of patients. Therefore, it is safer to admit all patients with an estimated blood loss of >200 mL to an intensive care unit (ICU). Third step is to identify patients who would not be appropriate candidates for resection surgery, such as those with impaired health status, disease progression (localized/disseminated malignancy) or diffuse lung bleeds suggesting a systemic problem.[4]

INVESTIGATIONS

Goals of investigations are to:

- Localize the bleeding focus.
- Identify the underlying pathology (infection vs. neoplasms vs. vasculitis).
- Initiate the definitive treatment as soon as possible.

Urgency of investigations is based upon the severity of bleeding, underlying cardiopulmonary reserve of the patient, high predilection for rebleed, and disease states (large vessels vs. small vessel disease). It is important to remember that hemoptysis is just an external manifestation of pulmonary bleeding and has got no correlation with extent of intrapulmonary hemorrhage.

DIAGNOSIS

The initial evaluation of massive hemoptysis should begin with basic history and physical examination.

History and Physical Examination

A good basic history and physical examination can aid in giving clues regarding the cause of hemoptysis. Important points to remember while taking history are age, history of smoking, alcoholism, fever, cough and sputum, hematuria, weight loss, history of any lung disease, previous history of such episodes, trauma, drug intake such as antiplatelets and anticoagulants, any underlying kidney or cardiac disorder, occupational or tobacco exposures, any familial lung or bleeding disorders. Salient features about the bleeding such as duration, amount, character, and frequency should be noted. Associated chest pain or lung sounds may specifically be felt on the side of bleeding.

Physical examination, when possible, may give clues regarding the cause of hemoptysis especially with decrease or absence of breath sounds, presence of adventitious sounds, bronchial breathing, and succussion splash, etc.

Pressure of saddle nose with rhinitis with septal perforation may indicate Wegener's granulomatosis. Presence of clubbing may indicate lung carcinoma or bronchiectasis. Presence of wheezing or stridor may indicate underlying tracheolaryngeal tumor or foreign body.

Laboratory Studies

Initial investigations during the workup of hemoptysis should include complete blood count, platelet count, liver function tests, kidney function tests, coagulation studies, urinalysis, electrocardiogram that may provide some hints regarding the presence of some systemic disorder. Serologies such as anti-GBM antibodies, antineutrophil cytoplasmic antibody (ANCA) may aid in diagnosing vasculitic disorder. Arterial blood gas analysis can give some clue regarding the severity of physiological derangement in gas exchange caused by hemoptysis. Sputum should be examined for the presence of bacteria (Gram stain, potassium hydroxide acid, and acid-fast bacilli). Sputum and blood cultures should be obtained especially for fungi and *Mycobacterium* if presence of infection is suspected.

Radiographic Studies

Chest radiography is a basic and readily available investigation that can easily be done at patient bedside. It is useful in localizing the site of bleeding by identifying pathologies such as cavitary lesions, tumors, infiltration, atelectasis, pneumonia, lung abscess. It is however found to be inconclusive (nonlocalizing or normal) in about 20–60% of patients with hemoptysis, only rarely does a massive hemoptysis occur in presence of a normal chest radiograph.

Computed Tomography

Computed tomography (CT) can be useful in demonstrating lesions which may not be visible in the chest radiograph such as bronchiectasis, aspergilloma, bronchogenic carcinoma. It may however be unwise to remove an unstable patient from ICU unless some therapeutic procedure is planned. In such situations it may be appropriate to proceed with bronchoscopic examination first which can be easily done bedside. Whenever feasible a contrast-enhanced CT of chest should be performed. It readily identifies pathologies such as thoracic aneurysm and arteriovenous malformations. It can more clearly delineate areas of infiltration, obstruction, and stenosis or may demonstrate masses, cavities, and obstruction, stenosis missed on a plain chest radiograph. It may also provide clues regarding pulmonary hypertension. CT chest has been found to identify abnormalities in 50% of patients with hemoptysis having normal chest radiograph and inconclusive bronchoscopic findings. Except for situations of life-threatening hemoptysis it is advisable to perform a CT chest

before proceeding with bronchoscopy. CT chest can aid in making the bronchoscopy more targeted to the suspected sites. Two major limitations with CT chest are (1) time required to obtain the scan and (2) supine positioning which may not be feasible in a bleeding patient with inability to clear secretions and oxygenation failure.[7,8]

Bronchoscopy

Bronchoscopy has long been considered as the initial method for diagnosis and localization in hemoptysis. The ideal time for bronchoscopy in hemoptysis however remains controversial. The general consensus is to perform an early bronchoscopy in patients presenting with rapidly deteriorating clinical course. A delayed bronchoscopy, i.e., within 24–48 hours of admission can be planned for patients who are clinically stable.

Second dilemma is regarding the type of bronchoscopy, i.e., rigid versus flexible. Due to the very nature of massive hemoptysis, it is desirable to perform a rigid bronchoscopy in controlled environment. This is for its better suctioning ability and maintenance of airway patency. On the other hand, with a fiberoptic bronchoscopy (FOB) it is essential to perform the procedure under minimal sedation and as quickly as possible. It should be initially directed toward the site of bleeding as identified by chest radiograph or CT scan. **Table 3** lists comparison of flexible and rigid bronchoscopy for evaluation of massive hemoptysis.[9]

Because of the limitations with both modalities, it might be worthwhile that these two modalities be combined to achieve optimal bleeding evaluation and control overall diagnostic accuracy of bronchoscopy in evaluating patients with hemoptysis is reported to be 10–43%.

Multidetector Computed Tomography Angiography

Recently multidetector computed tomography angiography (MDCTA) has emerged as a useful tool in providing a detailed mapping of the thoracic vasculature. As compared to FOB, it is not only successful in identifying the site but is able to provide insight into the etiology of bleed, and therefore can impact the line of treatment. Conventionally MDCTA had been used to study the bronchial arteries and nonbronchial systemic arteries (NBSAs) for assessing the system circulation in patient with hemoptysis. However, attempts have been made recently to study, the pulmonary arterials bleed also. In a prospective study, contrast CT was accurate in about 84% of patients in identifying the feeding vessel between nonbronchial system arterial and pulmonary arterial supply in massive hemoptysis.[10,11]

Bronchial Arteriography

Before the advancement in arteriographic technology, it was a norm to perform bronchial arteriography (BA), followed by pulmonary arteriography if BA did not reveal the source. In majority of cases of massive hemoptysis, the bleeding source is from systemic circulation, either from the bronchial arteries or collateral branches of subclavian, axillary, intercostals or phrenic arteries. Systemic bilateral angiographic examinations of the bronchial and nonbronchial collaterals have been useful in precise identification of the bleeding vessel. The load of contrast dye is however quite high with this approach, and most of the times embolization is based on clinical and radiographic findings as contrast extravasations is rarely seen on arteriography. Pulmonary artery angiograms are usually performed if there is a negative bronchial angiogram, suspicion of Swan–Ganz catheter tears (sealed) or aneurysm or arteriovenous malformations.[12]

MANAGEMENT OF MASSIVE HEMOPTYSIS (FLOWCHART 1)

Every hemoptysis needs meticulous evaluation as it has the potential to become life threatening. And there is no way to predict this fatal course. It is therefore essential to observe these patients in an ICU or high dependency unit for at least 24 hours.

The usual straightforward indications for ICU admissions are huge hemoptysis volume, need for mechanical ventilation, hemodynamic instability, need for blood transfusions, underlying limited cardiopulmonary reserve of the patient. These conditions also signal need for rapid evaluation and treatment. There are basically five primary objectives for management of massive hemoptysis: prevention of asphyxiation, localization of the bleeding site, arrest of bleeding, identification of the cause of bleeding and its definitive therapy-surgical or medical.

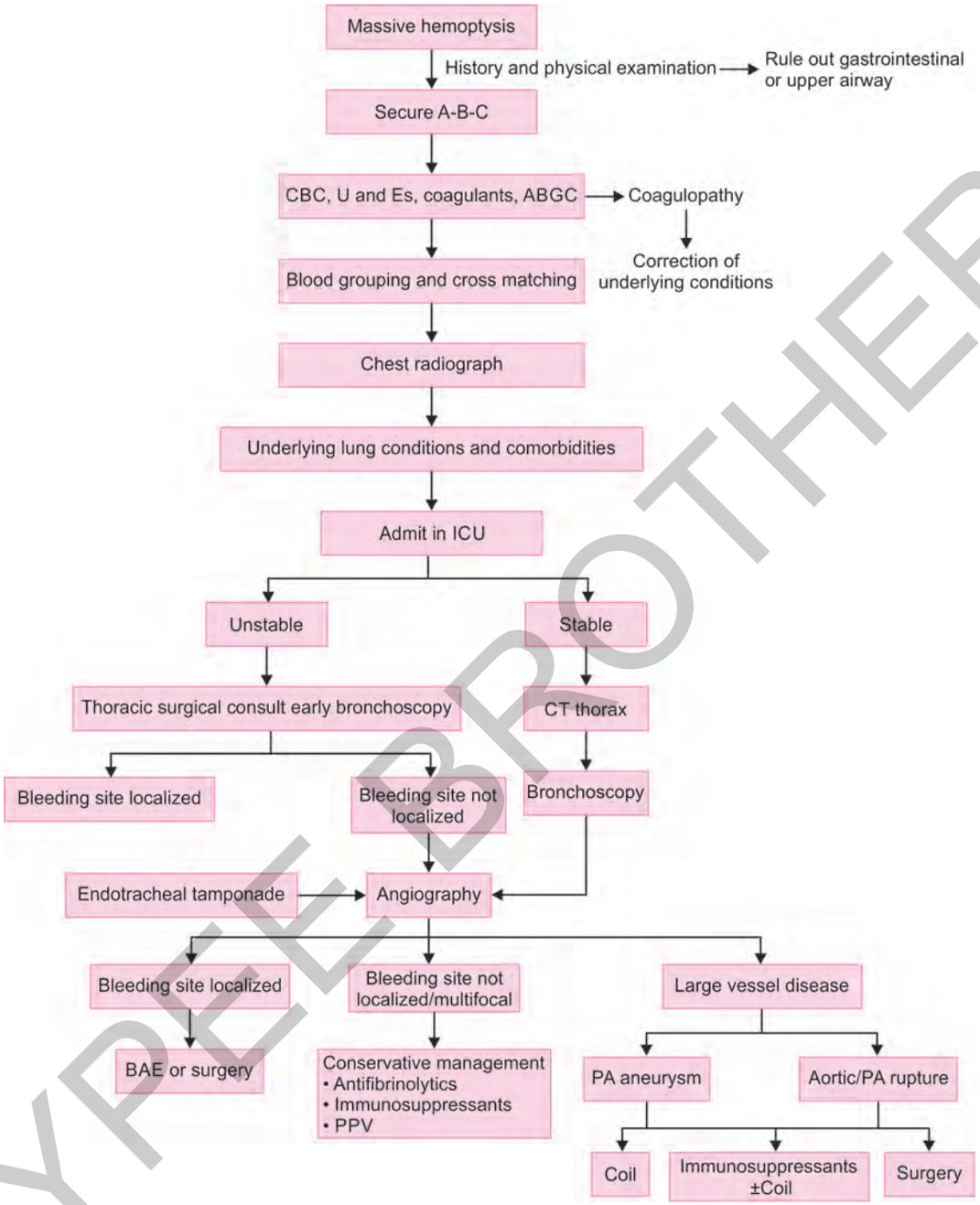
General Supportive Management

A large intravenous cannula should be secured and blood should be sent for cross matching. The availability of the type and cross-matched blood should be ensured with the blood bank. Hypoxemia should be corrected with supplemental oxygen and a baseline blood gas measurement should be obtained. Blood and

TABLE 3: Comparison of flexible and rigid bronchoscopy for evaluation of massive hemoptysis.

	Flexible bronchoscopy	*Rigid bronchoscopy*
Pros	• Can be performed bedside under local anesthesia • Can reach the upper lobes and lesions located as far as the 6th bronchial generation • Efficacious in rapidly evaluating central bronchial lesions	• Better airway protection for episode of bleeding • Better airway suctioning for clots, fresh bleeding • Positive-pressure ventilation can be provided • Rapid institution of lung isolation with bronchial blockers or double lumens end tracheal tubes • Allows passage of balloon catheters, instillation of large volumes of ice-cold lavage solutions • Allows passage of flexible bronchoscope
Cons	• Minimum suction capacity • Difficulty in localizing the bleeding site because of excessive blood in the bronchi • May induce coughing which can aggravate hemoptysis	• Requires general anesthesia • Physician experience limited • Equipment setup delay • Cannot visualize beyond trachea and main bronchi

Flowchart 1: Algorithm for management of massive hemoptysis.



(ABG: arterial blood gas; BAE: bronchial-artery embolization; CBC: complete blood count; CT: computed tomography; ICU: intensive care unit; PA: pulmonary artery; PPV: positive pressure ventilation; U and Es: urea and electrolytes)

fluids should be transfused as necessary. After identifying the side of bleeding with the help of a chest radiograph, patient should be positioned with the head down on side of bleeding. This is done to avoid spillage of blood into the unaffected lung. Patient should be timely intubated with a large endotracheal tube > 8 mm in internal diameter if patient develops respiratory distress, refractory hypoxemia, continuous hemoptysis, depressed consciousness and inability to clear airway secretions, hypovolemic shock, rising carbon dioxide concentration in blood. Cough suppressants have generally been used to avoid large swings in intrathoracic pressure associated with cough, which may cause dislodgement of the clot resulting in fresh bout of bleeding. However, this may result in clot retention with possibility of underlying lung collapse. Once the patient airway is secured the patients can be put on mild sedation. After being put on ventilator use of antitussives and patient positioning are more controversial. Bronchodilators should generally be avoided as they have vasodilatory actions and may cause renewed bleeding. Systemic hypertension, if present should be treated, and other specific measures for obvious causes of bleeding should be instituted such as reversal

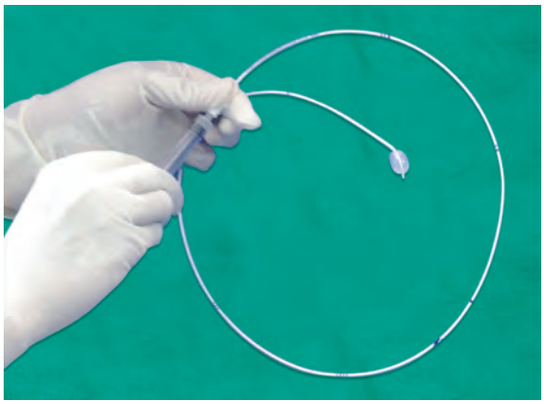


Fig. 1: Fogarty catheter (with balloon inflated) used for isolating lung/segment.

Fig. 2: Double lumen tube.

of anticoagulation and antitubercular treatment, etc. Patients with pre-existing lung disorders such as bronchitis or bronchiectasis having leukocytosis or fever should be adequately covered with broad-spectrum antibiotics, as infection is known to precipitate hemoptysis in such conditions. Aspirin, nonsteroidal anti-inflammatory drugs, and anticoagulants should be discontinued. Coagulopathy should be appropriately and adequately reversed with the administration of blood products such as platelets, fresh frozen plasma, cryoprecipitate, use of vitamin K, desmopressin, etc. Antifibrinolytics such as tranexamic acid, an inhibitor of plasminogen activation have been used frequently to control hemoptysis. Intravenous vasopressin has also been used at many centers but should be avoided in patients with underlying coronary artery disease, and if BAE is planned as the vasoconstriction may obscure the site of bleeding. Recombinant factor VII has also been used to control bleeding in diffuse alveolar hemorrhage, chest trauma, and cystic fibrosis in many centers. FDA does not approve it for use in hemoptysis and one must keep in mind its risk benefit ratio, and other alternatives available when considering this option. Intravenous estrogens have also been used for the same purpose.

In difficult to oxygenate cases, extracorporeal membrane oxygenation (ECMO) can be used as a bridging measure.

Definitive Medical Management

Invasive therapeutic measures do not have any role in control of the pulmonary hemorrhage secondary to coagulopathies, blood dyscrasias or immunologically mediated alveolar hemorrhage such as in Goodpasture's syndrome. Appropriate medical therapy in form of blood transfusion, reversal of anticoagulation, systemic steroids, cytotoxic agents or plasmapheresis is usually sufficient. In catamenial hemoptysis use of long-term administration of danazol or gonadotropin-releasing hormone (GnRH) has been found to be useful.

Lung Protection

Sometimes, additional measures are needed to prevent contamination of the contralateral lung with blood, and to maintain oxygenation despite endotracheal intubation and mechanical ventilation. In such situations, rapid identification of the bleeding side by bedside chest radiograph is followed by selective mainstem intubation. Selective emergent bronchial intubation is the easiest on the right side as the leftward displacement of carina in most individuals almost always allows blind advancement of endotracheal tube into the right main bronchus.

Selective mainstem intubation should ideally be done with the help of a bronchoscope. One has to be careful of right upper lobe atelectasis in patients requiring right mainstem intubation. Another strategy includes passage of a Fogarty catheter beside the endotracheal tube. It can be further directed into the left main bronchus with the help of bronchoscope passed through the endotracheal tube. The balloon of the catheter can then be inflated, and right lung can then be isolated **(Fig. 1)**. There are many bronchial blockers available for the same purpose such as Magill's, Wiruthan, etc. Bronchial blockers isolate bronchial tree at the lobar level. Bronchial blockage not only allows time for definitive treatment, but may also have a tamponading effect on bleeding source.

Double-lumen Endotracheal Tubes

Double-lumen endotracheal tubes have also been found to be useful in managing patients with massive hemoptysis. These prove to be quite successful in independent isolation of each main stem bronchus allowing single lung ventilation and isolation of the nonbleeding lung **(Fig. 2)**. The proper positioning however requires adequate training and experience. Pediatric flexible bronchoscope can be used to guide its placement.

BRONCHOSCOPIC TREATMENT

Ice-cold Saline/Adrenaline Lavage

Ice-cold saline lavage has been found useful in providing time for evaluation of the disease, localizing the bleeding and facilitating lung isolation, surgery or bronchial/pulmonary angiography as needed. It usually results in removal of clots, improvement in oxygenation and slowing or arresting the bleeding. It is usually performed with a rigid bronchoscope and a large bore suction catheter. One liter of ice-cold saline is mixed with 1 mg of adrenaline. All blood clots and secretions are suctioned from the tracheobronchial tree with the help of suction catheter. Adequate arterial saturation is obtained first. It is followed by intubation of bleeding side. Blood clots are suctioned from the intubated side

followed by instillation of large aliquots (50–100 mL) of the iced adrenaline saline solution down the bronchoscope left in for a period of 10–15 seconds and then rapidly suctioned out. After this the nonbleeding lung is reintubated and ventilation is resumed. This process is continued with rapid switching from ventilation to lavage and back. If the bleeding settles both lungs can then be ventilated and attempts should be made to localize the bleeding to a particular lobe. An FOB can then be passed through the rigid bronchoscope or the endotracheal tube to aid in localization. Thereafter FOB can be used to wedge the culprit lobe, and selective lavage can be continued in a similar fashion.[13]

Endobronchial Infusion

The topical application of thrombin and fibrinogen—thrombin mixtures has been used in various centers to provide hemostatic clot in the region of bleed with some success. Oxidized regenerated cellulose mesh that is a biodegradable cellulose fabric has also been used as an alternative procoagulant in such cases. After deployment into the area of hemorrhage, it absorbs blood and swells into a gelatinous mass, which promotes tamponade and coagulation. Other agent commonly used is n-butyl cyanoacrylate, which is biocompatible glue with prothrombin properties.

Topical vasoconstrictors such as vasopressin or vasopressin derivatives have also been used anecdotally. All these measures may be undertaken in patients who do not have immediate access to BAE or surgery, or those who need temporizing intervention until definitive treatment modality is available.

Laser Photocoagulation

Sporadic success has also been reported with the use of neodymium-doped:yttrium aluminum garnet (Nd:YAG) or argon plasma laser in patients with persistent hemoptysis. Aggressive photocoagulation of endobronchial site may be the only option for palliative treatment of bleeding associated with tumors in which chemotherapy and radiotherapy have been exhausted. Appropriate training and patient selection are however a must to prevent catastrophic complications such as vessel perforation or tracheal fire. It has been associated with a success rate of approximately 60% in cancer patients. Precision-guided laser beam therapy may be difficult due to poor visualization of bleeding artery in massive hemoptysis.

Endotracheal Balloon Tamponade

If FOB is successful in localizing the bleeding to the segmental bronchus level, endotracheal tamponade may be tried with balloon tipped devices known as bronchial blockers. Several type of such devices are available. Fogarty type embolectomy catheter, wire guided bronchial blocker, and a single lumen endobronchial tube with a movable bronchial blocker. Bronchoscopic guided placement of these catheters into the bleeding segment followed by balloon inflation can be used to contain the bleed. Multiple catheters can be placed if the source is multifocal. These catheters can be left in place for 24–48 hours or until the bleeding is controlled. It is only a temporizing measure while the diagnostic workup continues and more definitive procedure can be employed. It may be applied to patients who are not surgical candidates, or to surgical patients for preoperative stabilization. Prolonged use of these catheters should be discouraged to avoid ischemic mucosal damage and postobstructive pneumonias.

Some case reports regarding use of endobronchial valves in hemoptysis exist in literature. Endobronchial valves are used in endoscopic lung volume reduction. Their use in hemoptysis remains anecdotal. Its use has also been found to be associated with pneumothorax. Cases using temporary airway stenting and instillation of oxidized regenerated cellulose have also been reported.

Bronchial-artery Embolization

Remy et al. first performed this procedure in 1973. In earlier days it was reserved for patients who were unfit for surgery due to advanced lung disease or multiple bleeding sites. These days it is viewed as the most effective nonsurgical method, and is procedure of choice in managing patients with massive hemoptysis. This is due to its good immediate and long-term results. The immediate success rate range from 64 to 100%, and recurrent nonmassive bleeding is reported in about 16–46% of patients.

A preliminary descending thoracic aortogram is obtained to visualize the bronchial arteries as well as NBSAs that supply parenchymal lesions. Angiographic features that suggests a source of bleeding include hypertrophic and tortuous, bronchial arteries neovascularity, hypervascularity, bronchial artery aneurysm shunting into the pulmonary vein and artery, and extravasation of contrast medium. These days super selective catheterization allows placement of catheter in bronchial artery. Various materials have been used for embolization such as gelatin sponge particles, polyvinyl alcohol particles, liquid embolic agents such as isobutyl 2 cyanoacrylate; polyurethane particles metal coils, fibrinogen thrombin mixtures. Polyvinyl alcohol particles are most frequently used worldwide. Complication of BAE includes chest pain, dysphagia, pyrexia, intimal tears, hemoptysis, vessel perforation, systemic embolization and neurological complications due to spinal cord ischemia due to inadvertent occlusion of anterior spinal arteries. Spinal cord ischemia is reported to be as high as 1.4–6.5% after BAE. Contraindications to bronchial artery angiogram are allergy to contrast medium, inability to accept dose of radiation from angiogram such as in pregnancy, if spinal arteries arise from bronchial arteries.[14]

SURGICAL MANAGEMENT

Given the high success rate of conservative management techniques such as endobronchial tamponade and BAE, practice of emergent massive surgery for hemoptysis has declined. It however remains the treatment of choice for management of hemoptysis due to TIF, leaking aortic aneurysm, arteriovenous malformation, hydatid cyst, penetrating chest injuries, iatrogenic pulmonary rupture, mycetomas resistant to other treatment trials, failed BAE or early recurrence of bleeding after BAE poor candidate for BAE such as spinal vessels originating from bronchial arteries, multiple feeder vessels, patients not able to tolerate the contrast load. Surgery is contraindicated in patients with inadequate cardiopulmonary reserve, diffuse diseases such as vasculitis, inoperable lung cancer due to direct spread to trachea, mediastinum, and great vessels.

Operation almost always requires a thoracotomy. Video-assisted thoracoscopic surgeries are usually avoided due to the emergent nature of procedure. Resection is usually a lobectomy or a pneumonectomy. Factors associated with poor surgical outcome are emergency procedure, pneumonectomy, need for mechanical ventilation in preoperative period, and salvage procedure after a failed BAE.

Contamination of the contralateral lung before, during, and after surgery results in postoperative respiratory failure leading to prolonged mechanical ventilation, hospital-acquired pneumonia, and death. Other difficulties encountered in emergency surgeries are due to formidable pleural adhesions, aortopulmonary collaterals, excessive blood loss, and requirement of an extensive resection in-patient with pre-existing lung disease. All these factors can results in a turbulent postoperative course. Therefore, the decision regarding surgery for massive hemoptysis is difficult, and has to be taken when all desired clinical information is not available.

In patients with limited pulmonary reserve or extensive pleural adhesions, physiological lung exclusion has been tried. In this approach, the bronchus and the pulmonary artery to the involved lobe/segment are surgically ligated leaving the pulmonary veins intact without lung resection. It has been found to be a viable option in high-risk surgical patients.

MISCELLANEOUS CONDITIONS

The onset of massive hemoptysis in a patient with tracheostomy is usually secondary to development of a tracheoarterial fistula, usually with the innominate artery. Anterior and downward pressure on the tracheal cannula and over inflation of the tracheostomy balloon should be promptly applied. These have been found to be useful in tamponading the bleeding vessel temporarily until the surgical intervention can be done. Attempts to deflate the tracheal cuff, and to remove the tracheostomy tube should be done under controlled conditions only.

In aspergilloma-induced hemoptysis direct instillation of antifungal agents with or without N-acetyl cysteine or iodine into the cavity has been associated with good success in controlling the bleeding. This can be done with an indwelling catheter placed either percutaneously or transbronchially. It is a viable option for massive hemoptysis in cavity-concealed aspergilloma in poor surgical candidates. Covered self-expanding stents have also been tried in patients who have failed BAE or surgery. These are used to occlude the bleeding site.[15]

Iatrogenic Pulmonary Artery Rupture

Although use of pulmonary artery catheter (PAC) has declined in ICU, it still remains a useful tool in evaluating sick patients. Incidence of iatrogenic pulmonary artery rupture (IPAR) varies between 0.1% and 0.47%. Mortality related to IPAR is as high as 50%, and in fact may be 75% if patients are on anticoagulants. Initial presentation may be a minor hemoptysis, or massive bleeding, or as hemothorax. The side of PAC will indicate toward side of bleeding. Generally PAC is located on the right side, lower lobe, it may be taken as the side of bleeding in emergency situation. Patient should be intubated and lung isolated. Fiberoptic bronchoscopy should be performed after that. CT scan followed by angiography with embolization is then done.

Tracheostomy Hemorrhage

This is another, not quite often, encountered cause of massive airway bleed in the ICU. Bleeding in the immediate postoperative period is usually related to injury to blood vessels such as anterior jugular or inferior thyroid vein, during incision. Hemorrhage after the first few week post-tracheostomy is mostly secondary to presence of TIF. In such a situation, tracheostomy tube can be replaced by an endotracheal tube, and cuff overinflated just above carina to have a tamponade effect. If the bleeding still persists, surgical intervention in the form of sternotomy and ligation of the bleeding vessel may be needed.[16]

Extracorporeal Membrane Oxygenation in Hemoptysis

Intensivists have used ECMO in bleeding patient to allow stabilization and definitive therapy. But we need to be mindful of increased bleeding predisposition as heparin is needed during ECMO, and in addition there may be loss of von Willebrand multimers during its prolonged use. Venovenous (VV) ECMO may be better than veno-arterial (VA) ECMO in such patients. ECMO, if used judiciously, may be invaluable in management of life-threatening hemoptysis.[17] On the other hand, sometimes ECMO itself may be the cause of massive hemoptysis. This should be managed by cessation of anticoagulation, correction of coagulopathy, transfusion of blood products followed by definitive treatment.[18]

Radiotherapy

There are reports in literature of use of radiotherapy for control of bleeding related to unresectable bronchogenic carcinomas, and fungal ball in tubercular activities.[18]

Intracavitary Treatment

Intracavitary instillation of potassium or sodium iodide has been used to control life-threatening bleeding secondary to aspergilloma, sarcoidosis, bronchiectasis, etc. in patients who are poor surgical candidates.[19]

OUTCOME

Factors influencing the mortality in massive hemoptysis are volume of blood expectorated, amount of blood retained within the lungs, rate of bleeding, underlying respiratory reserve of the patient. The mortality is as high as 58% in patients with hemoptysis volume of 1,000 mL in 24 hours as compared to 9% in those with hemoptysis volume < 1,000 mL in 24 hours. Massive hemoptysis is associated with higher mortality if it is secondary to malignancy (approximately 58%) than with than other causes such as bronchiectasis and pulmonary infection (1–38%). Mortality is also higher if patients are managed conservatively as compared to those who receive definitive therapy in the form of BAE or surgery.

CONCLUSION

The clinical approach for the management of massive hemoptysis should include timely confirmation of diagnosis by history and physical examination, chest X-ray, bronchoscopy or CT. Patients with unstable vitals should be treated aggressively with

intubation, volume resuscitation, blood transfusion, correction of coagulopathy, bronchoscopy, and endotracheal tamponade. Since endobronchial control measures and BAE have radically changed the outcome they remain the procedures of choice. It is imperative to accurately identify the surgical candidates to allow an elective procedure with lower morbidity and mortality, if the above interventions fail.

KEY POINTS

- Death in massive hemoptysis is due to asphyxiation rather than exsanguination.
- Decision making usually requires multidisciplinary involvement.
- Multislice CT is the diagnostic imaging modality yielding maximum information regarding the site and cause of bleeding.
- Primary aim is to stabilize and ensure adequate oxygenation with airway control followed by definitive therapy.
- Endobronchial therapy and angioembolization have significantly changed the management of massive hemoptysis.
- Lung resection for hemoptysis is associated with high mortality.

ONLINE REFERENCES

To access the references of this chapter online, kindly refer to page no. XXXIII for scanning the QR code.

Textbook of
CRITICAL CARE
Including Trauma and Emergency Care

Key Features

- Descriptions are supported by relevant diagrams, tables, boxes and images for easy understanding
- Book is segmented into 14 sections, which are further divided into 124 chapters
- Cross reference of chapters in relevant contents have been mentioned
- Updated information with latest references have been incorporated
- This edition added 15 new chapters to previous edition of the book. These are Neuroimaging in Critical Care, Noninvasive Ventilation, Shock and Multiorgan Dysfunction Syndrome, Extracorporeal Therapies in ICU, Critical Care Issues in Elderly and Obese Patients, COVID-19 Disease, Fluid Physiology and Disorders of Sodium in the Critically Ill, Electrolyte Disorders in ICU, Gastrointestinal Emergencies, Perioperative Care of Patients Undergoing Lung Transplant, Renal Transplant: An Overview and Post-surgical Critical Care, Hematopoietic Stem Cell Transplantation, Newer Antimicrobials, Medication Overdose and Communication and Consents in the Intensive Care Unit
- Special emphasis is given to trauma and toxicology as these domains are important in clinical practice as well as commonly asked in examinations of critical care courses and fellowships
- Cardiac critical care section is supplemented with images of relevant ECGs and echocardiography which immensely elucidate the subject
- Incorporation of "Key Points" summaries at the end of each chapter to keep book handy
- References of chapters are provide online which can be accessed by QR code scan.

Yatin Mehta MD MNAMS FRCA FAMS FICCM FIACTA FTEE is Chairman, Medanta Institute of Critical Care and Anesthesiology, Medanta—The Medicity, Gurugram, Haryana. He is one of the pioneers in critical care and cardiac anesthesia in India. He trained at UCMS and AIIMS New Delhi, India; Queen University Hospital, Nottingham, UK and then Odense University Hospital, Denmark, before returning to India to start Escorts Heart Institute, department of Critical Care and Anesthesia. After 20 years, he moved to establish the same specialties at Medanta—The Medicity, Gurugram, Haryana, India. He has been visiting consultant at Uppsala Cardiothoracic Department, Uppsala University Hospital, Sweden, many times. He is on the editorial board of many journals. He has had more than 25 chapters in books, 330 publications and approximately 500 presentations in conferences and many orations. He is co-author of many guidelines. He has edited several books in Critical Care (Textbook of Critical Care, Atlas of Critical Care, MCQs in Critical Care, Pocket Book of Critical Care, Prevention of Healthcare Associated Infections, MCQs in Infectious Diseases). He is on editorial board of many journals. He is teacher and examiner for Fellowship in Critical Care and Cardiac Anesthesia, National Board of Examinations, ISCCM and IACTA and DM Examiner, Tribhuvan University, Nepal. He is Adjunct Professor, National Board of Examinations, India. He was awarded FAMS by National Academy of Medical Sciences, New Delhi in 2002. He was awarded with FIACTA (Honorary) by Indian Association of Cardiovascular Thoracic Anaesthesiologists in 2009, FICCM (honorary) by Indian College of Critical Care Medicine and Fellowship in TEE (honorary) by Indian Association of Cardiovascular Thoracic Anaesthesiologists in 2010. He is President of Sepsis Forum of India and The Simulation Society of India (TSS) and was Chairman Swac-Eslo. He is the past President of ISCCM, President of Research Society of Anaesthesiology and Clinical Pharmacology (RSACP), Indian Association of Cardiovascular Thoracic Anaesthesiologists (IACTA) and ISA, Gurugram branch. He has received several awards for his contribution to his field. He has been awarded with 'Medical Doctor of the year 2010'; 'Vashishta Chikitsa Ratan Award' by DMA in 2012; Dronacharya Award in 2019; and The Guardian of Health Award in 2021. He is well-known name in Critical Care with many years of work, research and academic experience in various aspects of Critical/Intensive Care.

Jeetendra Sharma MD IDCCM IFCCM FICCM is the Chief Critical Care and Chief Medical Quality, Artemis Hospital, Gurugram, Haryana, India. He had completed MD in Anesthesiology from Dr SN Medical College, Jodhpur, Rajasthan and Indian fellowship critical care from Fortis Escorts Heart Institute, New Delhi and Indraprastha Apollo Hospital, New Delhi. He worked at Medanta—The Medicity, Gurugram as Senior Consultant Critical Care then he moved to Artemis Hospital, Gurugram there he is working as Chief Critical Care and Chief Medical Quality. He has several national and international research publications to his credit. He has co-edited Atlas of Critical Care and written many chapters for various critical care books. He is the teacher of DNB critical care, IFCC and IDCC. He received Hansraj Nayyar Memorial Award 2009, India Healthcare Award 2014, Healthcare Award 2018, Corona Warrior Honour 2020 and Iconic Healthcare Leader Award 2021.

Chitra Mehta MBBS DNB (Resp Med) FNB (Crit Care Med) is Director, Critical Care at Medanta—The Medicity, Gurugram. She has nearly 20 years of experience in Critical Care. After her MBBS, she completed DNB in Respiratory Medicine, and Post-doctoral fellowship by NBE in critical care medicine. She has given many national and international presentations. She has multiple national and international publications to her credit. She has authored many chapters in various books on critical care. She is the co-editor of 'Pocketbook of Critical Care: An Indian Perspective' published by Knowledge Source Pvt. Ltd. She is a recognized ISCCM and NBE teacher for various courses in critical care. She was awarded 'Junior Scientist Award' in NAPCON 99. She was also recipient of Best Oral Paper Award in SLEEPCON 1.

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