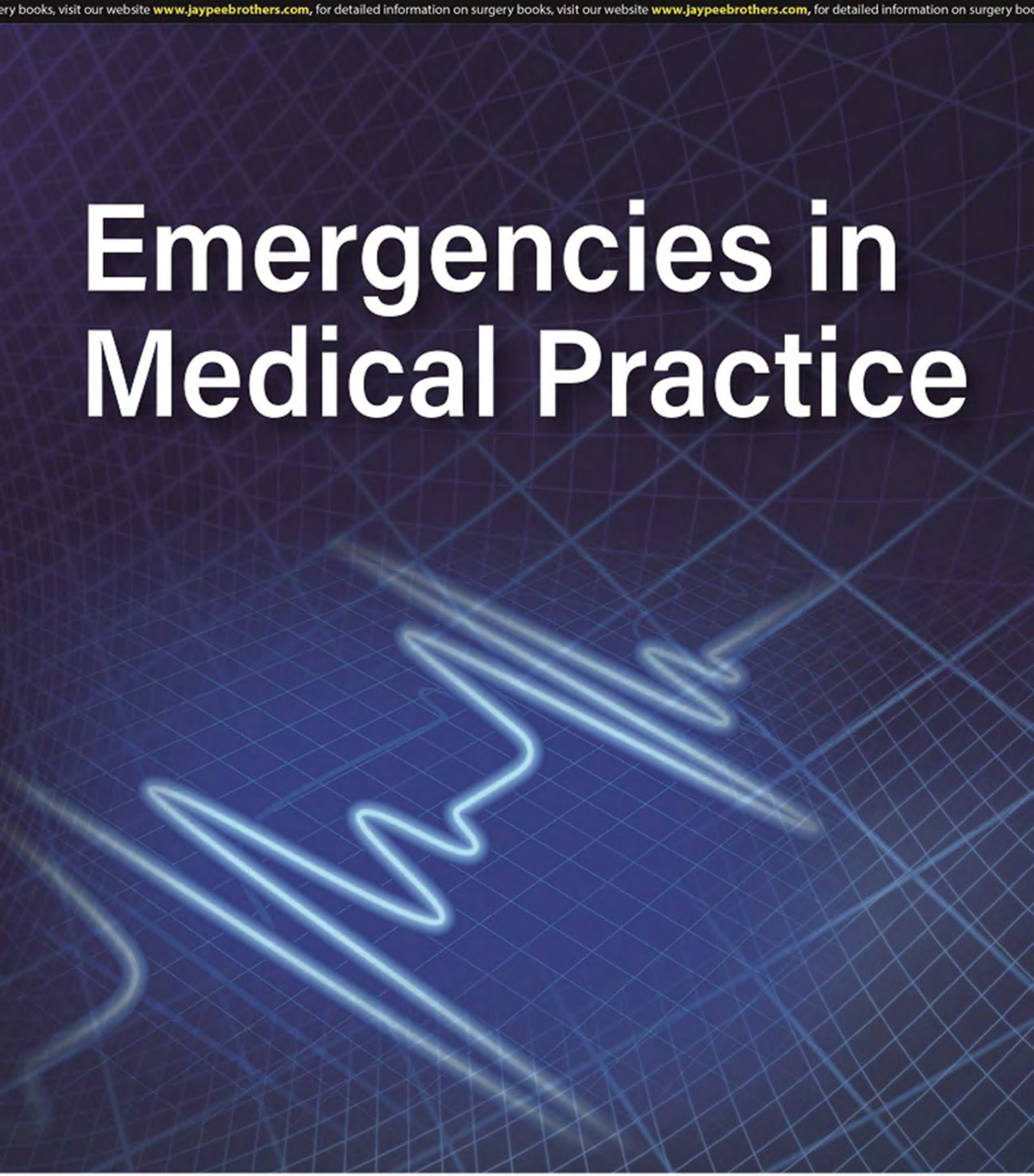
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Emergencies in Medical Practice



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Contents

Section 1 Cardiological Emergencies

Section Editor: *Anjan Lal Dutta*

1. **Cardiac Arrest and Cardiopulmonary Resuscitation** 3
   Pradeep Singh
2. **Approach to Syncope** 17
   Kallol K Dey
3. **Acute Coronary Syndrome: ST-elevation Myocardial Infarction** 29
   Sunil Lhila
4. **Acute Heart Failure** 34
   Vernon VS Bonarjee
5. **Cardiac Tamponade: Diagnosis and Management** 40
   Shilanjan Roy, Srina Ray, Saumitra Ray

Section 2 Respiratory Emergencies

Section Editor: *Ajoy Krishna Sarkar*

6. **Emergency Airway Management** 49
   Namrata Biswas
7. **Respiratory Failure** 57
   Tamoghna Banerjee
8. **Respiratory Emergencies** 61
   Ajoy Krishna Sarkar, Abhraneel P Guha, Sanjukta Dey, Pratik Biswas
9. **Massive Hemoptysis** 70
   Rishika Pal, Bhaswati Dasgupta Nath
10. **Acute Pulmonary Embolism** 77
    Avijit Das
11. **Acute Exacerbation of Asthma** 85
    Sanjukta Dey

Section 3 Neurological Emergencies

Section Editor: *Goutam Gangopadhyay*

12. **Approach to an Unconscious Patient** 95
    Chintha Venkata Sriram, Goutam Gangopadhyay
13. **Status Epilepticus** 104
    Haseeb Hassan

14. **Stroke** 111
Shankha Shubhra Chaudhuri

15. **Acute Meningitis** 118
Jasodhara Chaudhuri

16. **Acute Encephalitis** 123
Arka Prava Chakraborty, Souvik Dubey

17. **Acute Migraine** 129
Adreesh Mukherjee

Section 4 Gastrointestinal Emergencies

***Section Editor:** Jayanta Mukherjee*

18. **Acute Abdomen: Approach** 137
Jayanta Mukherjee

19. **Acute Gastrointestinal Hemorrhage: Approach** 142
Jayanta Mukherjee

20. **Acute Pancreatitis: Approach** 146
Jayanta Mukherjee

21. **Acute Hepatic Failure** 150
Vikas Prakash

Section 5 Nephrological Emergencies

***Section Editor:** Pratim Sengupta*

22. **Acute Renal Failure** 157
Pratim Sengupta, VK Mohun, Sumanta Biswas

23. **Drugs and Kidney** 168
Pratim Sengupta, VK Mohun, Sumanta Biswas

Section 6 Metabolic Emergencies

***Section Editor:** Ghanshyam Goyal*

24. **Metabolic Emergencies (Electrolyte): Hyponatremia, Hypernatremia, Hypokalemia, and Hyperkalemia** 177
Pankaj Singhania, Piyas Gargari, Sujoy Ghosh

25. **Metabolic-hyperglycemic Emergencies** 187
Sanjay K Shah, Vivek Shah

26. **Endocrinal (Hypoglycemia)** 193
Ghanshyam Goyal, Usashi Biswas Bose, Rekha Basak Srivastava

Section 7 Gynecological Emergencies

***Section Editor:** Aruna Tantia*

27. **Gynecological Emergencies** 203
Aruna Tantia, Sunipa Chatterjee, Ushasi Mukherjee

Section 8 Trauma

Section Editor: *Subhasish Deb*

28. Road Traffic Accidents **215**
Subhasish Deb

29. Household Trauma **218**
Subhasish Deb

Section 9 Psychiatric Emergencies

Section Editor: *Sanjay Garg*

30. Violence in Mental Health **223**
Sanjay Garg

Section 10 Ophthalmological Emergencies

Section Editor: *Jitendra Shah*

31. Ophthalmic Emergencies **231**
Jitendra Shah

Section 11 ENT Emergencies

Section Editor: *Ramanuj Sinha*

32. Emergencies in ENT **237**
Ramanuj Sinha, Titas Kar, Tanya Panja, Preethi Rubinath

32.1 Foreign Bodies in ENT: A Nightmare for Patients and Doctors Alike! **237**
Ramanuj Sinha, Titas Kar

32.2 Tracheostomy **240**
Ramanuj Sinha, Tanya Panja

32.3 Otalgia **242**
Ramanuj Sinha, Preethi Rubinath

Section 12 Pediatric Emergencies

Section Editor: *Arun Kumar Manglik*

33. Pediatric Emergencies **247**
Arun Kumar Manglik, Gautam Ghosh, Mihir Sirkar, Nitin Manglik

Section 13 Rheumatological Emergencies

Section Editor: *Sukumar Mukherjee*

34. Emergencies in Rheumatological Practice **257**
Parthajit Das, Sukumar Mukherjee

Section 14 Miscellaneous Emergencies-1

Section Editor: *ML Saha*

35. Burns **267**
Kamal Singh Chhajer

36. Postoperative Emergencies **276**
Prakash K Sasmal, Pankaj Kumar

Section 15 Miscellaneous Emergencies-2

Section Editor: *Dipashri Bhattacharya*

37. Code Blue and Crash Cart **289**
Namrata Biswas

38. Anesthetic Emergencies **292**
Dipasri Bhattacharya

Section 16 Miscellaneous Emergencies-3

Section Editor: *Om Tantia*

39. Unknown Poisoning **305**
Nandini Chatterjee

40. Snakebite: Initial Management, Myths, and Reality **309**
Dayal Bandhu Majumdar

41. Anaphylaxis **316**
Shambo Samrat Samajdar, Sougata Sarkar, Saibal Moitra, Santanu K Tripathi

42. Emergencies in Medical Practice: Common Drugs **322**
Lopamudra Chowdhury

43. Emergency Management of Drowning **328**
Sarbajit Ray

Index *333*

CHAPTER 9

Massive Hemoptysis

Rishika Pal, Bhaswati Dasgupta Nath

DEFINITION

Hemoptysis is defined as expectoration of blood from the pulmonary parenchyma or tracheobronchial tree below the level of glottis.

Greek word "haima", meaning blood and "'ptysis" meaning spitting. Hemoptysis can range from blood streaking of sputum to the presence of frank blood in the absence of any accompanying sputum.[1]

The lungs have dual bloody supply, namely the bronchial and pulmonary circulation, respectively. Most of the massive hemoptysis incidentally arises from the bronchial circulation, which being a high-pressure system and which facilitates neovascularization of tumors and/or dilated airways in bronchiectasis or cavitary lesions, precludes the possibility of cessation of bleeding by simple measures.

From accumulated data and systematic reviews, it has been observed that 4.8–14% of patients presenting with hemoptysis tend to have massive hemoptysis,[2] which, however remains debatable considering the heterogeneity of studied populations. Amongst various etiologies, tuberculosis, bronchiectasis, lung abscesses and mycetomas remain consistent as culprits of massive hemoptysis.[3]

Massive hemoptysis sometimes involves both circulatory and respiratory system leading to death by asphyxiation or exsanguation.[4,5] Massive hemoptysis is a common emergency complaint, but only 1–5% of cases are massive or life threatening. In these cases, the mortality rate approaches nearly 50–100%, if prompt intervention is not executed.[6] In 90% of cases, it arises from the high-pressure bronchial circulation. In another 5% of cases, it arises from causes related to the aorta, such as ruptured aneurysm or aortobronchial fistulae, or from nonbronchial systemic circulation pertaining to intercostal arteries, coronary arteries, thoracic arteries and/or phrenic arteries, while in the rest 5% of cases, it arises from the pulmonary vessels.[7,8]

There are a multitude of patterns of bronchiolar arteriolar anatomy according to literature. The most common of them being a single intercostal trunk on the right giving rise to the right bronchial arteries and a single left bronchial artery in 30.5%. The second most common pattern being an intercostal trunk on the right yielding the right bronchial artery and a second common trunk from which right and left bronchial arteries arise (25%); In 12.5% of cases, a right intercostal trunk giving rise to a bronchial artery and two bronchial arteries on the left.[9]

Massive hemoptysis in cystic fibrosis is reported to have annual incidence of 0.9–4.1%.[10,11]

Massive hemoptysis categorically has been stated as either >400 mL in 24 hours or >150 mL in a single episode,[12] that is potentially acutely life threatening usually results due to bleeding from a bronchial artery in 90% of cases, most commonly due to bronchiectasis, tuberculosis, bronchogenic carcinoma and fungal infections.

ETIOLOGY

Studies by Rao[13] in 1960, suggested that tuberculosis had remained the most common cause of hemoptysis in India. The scenario still remains the same today. On the contrary nontubercular causes such as malignancy, bronchiectasis and pneumonia remains more common causes of hemoptysis in developed countries.

The various causes of hemoptysis are illustrated is **Table 1**.

- *Pulmonary tuberculosis:* It is the leading cause, wherever the disease is endemic.[15] Here, the cause of bleeding is usually bronchiolar ulceration with necrosis of adjacent blood vessels or rupture of a Rasmussen's aneurysm **(Fig. 1)**.[16] In the latter, weakening of pulmonary arterial wall is accountable for the same with a prevalence of 5%[17] and it must be taken into consideration wherever cavitary tuberculosis is suspected or diagnosed.
- *Bronchiectasis:* Chronic airway inflammation mediated by neutrophils, T-lymphocytes and cytokines causing tortuosity and permanent dilatation of the bronchial tree, owing to release of elastase and collagenase.
- *Fungal infections:* These are more prevalent among immunocompromised individuals or those with preexisting cavitary lung disease. Among these, the most

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TABLE 1: Etiology of hemoptysis.

Causes	*Examples*
Infections	Mycobacteria, mycetomas, lung abscess (*Klebsiella, Pseudomonas, Streptococcus, Actinomyces*), Bacterial endocarditis, paragonimiasis, hydatid cyst
Neoplastic	• Bronchogenic carcinoma • Endobronchial tumors (carcinoid, adenoid cystic carcinoma) • Pulmonary metastases • Sarcoma
Pulmonary causes	• Bronchiectasis (including cystic fibrosis) • Chronic bronchitis • Alveolar hemorrhage and underlying causes • Diffuse alveolar damage
Hematology	• Coagulopathy, platelet disorders • Thrombotic thrombocytopenic purpura
Trauma	• Catheter-induced PA rupture • Blunt or penetrating chest injury • Transtracheal procedures • Iatrogenic secondary to interventional pulmonology procedures • Bronchoscopic biopsy
Vascular	• Pulmonary and bronchial arterial aneurysms • Pulmonary infarct (embolism) • Pulmonary hypertension • Congenital cardiac or pulmonary malformations • Airway-vascular fistulae, arteriovenous malformations, Mitral stenosis • Left-ventricular failure • Pulmonary veno-occlusive disease
Drugs and toxins	• Penicillamine • Solvents • Crack cocaine • Trimellitic anhydride • Bevacizumab • Isocyanates • Nitrofurantoin
Vasculitis/ Collagen vascular diseases	• Granulomatosis with polyangiitis • Goodpasture's syndrome • Behçet's disease • Systemic lupus erythematosus • Essential mixed cryoglobulinemia • Henoch-Schonlein purpura • Mixed connective tissue disease • Progressive systemic sclerosis • Rheumatoid arthritis • Systemic necrotizing vasculitis • Immune complex associated glomerulonephritis • Pauci-immune glomerulonephritis
Miscellaneous	• Cryptogenic • Endometriosis • Lymphangioleiomyomatosis • Broncholithiasis, foreign body aspiration • Lung transplantation • Tuberous sclerosis • Idiopathic pulmonary hemosiderosis, catamenial • Hemoptysis (pulmonary endometriosis)[10,14]



Fig. 1: A Rasmussen's aneurysm (white arrowhead) originating from a small pulmonary artery branch (arrow) over the left upper lobe. Adjacent contrast medium extravasations (black arrowhead) indicate rupture of the aneurysm.

common cause is an aspergilloma.[18] Other offending causes include histoplasmosis and blastomycosis.

- *Bronchogenic carcinoma:* This is common with large and centrally located tumors, especially squamous cell carcinoma. In the setting of malignancy, myriad pathological factors play a role in influencing the volume and rate of bleeding, such as neovascularization in and relative to neoplasm, exfoliation of tumor surface, tumor necrosis, erosion of airways into surrounding vascular structures.
- *Immunologic lung diseases:* Goodpasture syndrome, Wegener's granulomatosis, systemic lupus erythematous (SLE), lupus pneumonitis, and microscopic polyangiitis.

APPROACH TO THE PROBLEM (FLOWCHART 1)

- Identify whether it is true hemoptysis
- Identify the severity of hemoptysis
- History and examinations
- Diagnostic investigations
- Appropriate management.[1,10,14]

Identifying True Hemoptysis

It should be below the vocal cords and persists as blood-tinged sputum. There should be a history of cardiopulmonary disease. Chest X-ray will reveal abnormal lung parenchymal lesion.

Identifying the Severity of Hemoptysis

- *Mild:* >100 mL blood loss per day
- *Moderate:* 100-150 mL blood loss per day
- *Severe:* Up to 200 mL blood loss per day
- *Massive:* >500 mL blood loss per day or >150 mL per hour or 100 mL blood loss per day for >3 days.

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History and Examination

Hemoptysis is the presenting symptoms for many different diseases.

History

- Acute onset of fever, cough, bloody sputum is suggestive of bronchitis or pneumonia. Productive cough is suggestive of bronchiectasis.
- Fever, nights sweats, history of travel from endemic region are suggestive of tuberculosis
- Dyspnea and pleuritic chest pain are suggestive of pulmonary embolism.
- Chronic weight loss, change in cough and extensive use of tobacco is suggestive of bronchogenic carcinoma.
- Minor hemoptysis with dyspnea is suggestive of mitral stenosis or alveolar hemorrhage diseases.
- Hemoptysis, hematuria with renal insufficiency suggests Goodpasture syndrome
- *Drug history:* Patients taking antiplatelets and/or anticoagulants have a higher preponderance to bleed. Ernst et al. in his study showed that 89% of patients taking clopidogrel and 100% of those taking both clopidogrel and aspirin respectively yielded higher rates of mild, moderate, and severe hemoptysis.[19]

Examination

- Start with checking the airway, breathing and circulation of the patient. Keep monitoring the vital signs side by side.
- Tachypnea is indicative or respiratory compromise with hypoxemia.
- Hypotension seen in massive hemoptysis.
- Cardiac examination reveals valvular heart diseases (diastolic murmur of mitral stenosis).
- Nasal and oral cavities should be examined properly to exclude out any extrapulmonary source of bleeding (pseudohemoptysis).

Diagnostic Investigations

- *Chest X-ray (PA and lateral view):* 20–30% patients with hemoptysis usually have normal chest X-rays. Abnormalities may include preexisting chronic lung diseases or infiltration resulting from pulmonary hemorrhage rather than identifying the cause for bleeding.
- *Arterial blood gas*
- *Complete blood count:* To rule out any thrombocytopenia and for evaluation of anemia/microcytosis (for any chronic blood loss or malignancy)
- *Coagulation profile:* To find out patients with history of coagulopathy or current use of anticoagulants.
- *Urea and electrolytes:* For the assessment of underlying kidney function.
- Electrocardiogram
- Urine analysis
- Bronchoscopy
- *Sputum* (fungal culture, Gram stain, acid fast bacilli smear, and cytology): If infective etiology is suspected.
- *High resolution computerized tomography (HRCT):* To find out any additional information/evidence which is not detected in the chest X-ray.
- *Nasal endoscopy, biopsy, CT or MRI* is indicated if the source of bleeding is from the upper airway for example nasal polyps, laryngeal carcinoma or pharyngeal tumor.
- *Other imaging:* Ventilation perfusion scan is an alternative procedure of CT in those selected patients with suspected pulmonary embolism.
- *Pulmonary or bronchial angiography:* It is useful if bleeding is ongoing and no source is found by other means.[1,10,14]

Appropriate Management (Flowchart 1)

Airway

The most lethal sequelae of hemoptysis is hypoxia due to ventilation-perfusion match which occurs due to small airways and alveoli getting flooded with blood. In such cases oxygen saturation is to be maintained at >94% by administering supplemental oxygen. In life-threatening hemoptysis, the airway has to be secured by large diameter (8 mm or larger) endotracheal tube (ETT) to allow for bronchoscopy if required, without jeopardizing the ventilation and oxygenation. In case of persisting bleeding and if the bleeding side can be localized, then ETT is advanced in the main stem bronchus of nonbleeding side, so as to improve the ventilation. It has been seen that the right main stem bronchus is easier to enter than the left bronchus.

Double lumen ETT, containing two small working channels, provides single lung ventilation and facilitates isolation of the bleeding side. However, these can get obstructed with clots and is hence not an effective tool for clot retraction.

Breathing

In patients with a known lateralizing source of bleeding, a mitigating "lung down" approach can be employed, where the patient is positioned with the bleeding lung in the dependent position. This will promote and protect the unaffected lung and thus will improve the oxygenation.

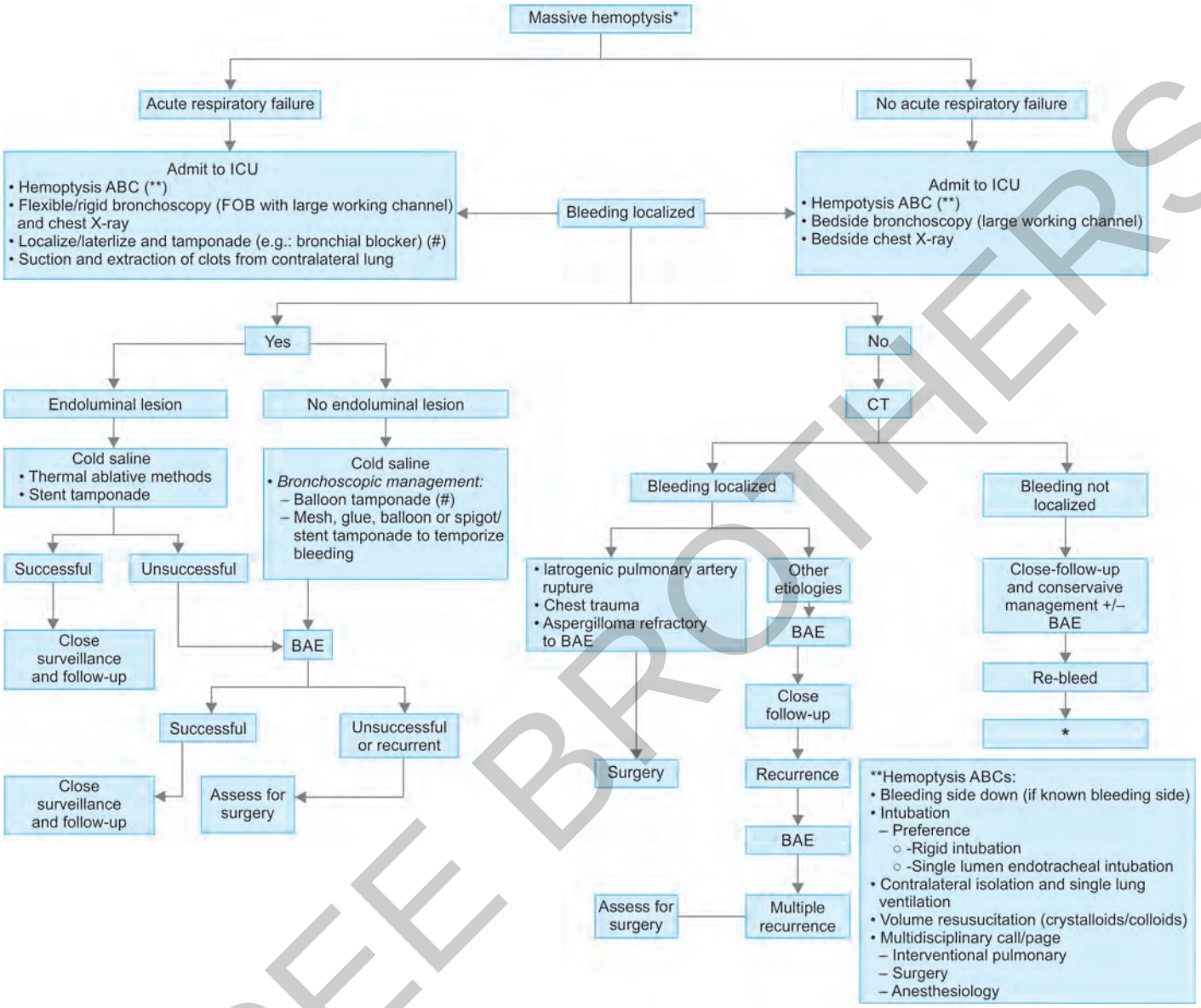
Circulation

Hemodynamic instability occurs due to massive hemorrhage, hence following measures can be taken:

- To secure an IV channel with a large bore cannula and crystalloids can be administered.
- Blood transfusion may be considered in patients with massive hemoptysis

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Flowchart 1: Algorithm for management of massive hemoptysis.



#Paralysis may be needed to maintain the position of the balloon, as well as prevent coughing until definitive management (BAE/surgery) is carried out
*Starting from the top of the diagram
**See ABC hemoptysis. BAE: bronchial artery embolization

- Any coagulopathy if present should be corrected
- Injection tranexamic acid 1 g intravenous bolus can be administered followed by oral tranexamic acid 500 mg 8 hourly.

Antibiotics

In case of mild hemoptysis due to bronchitis or bronchiectasis, the administration of antibiotics should be considered, if there is any evidence of bacterial infection.

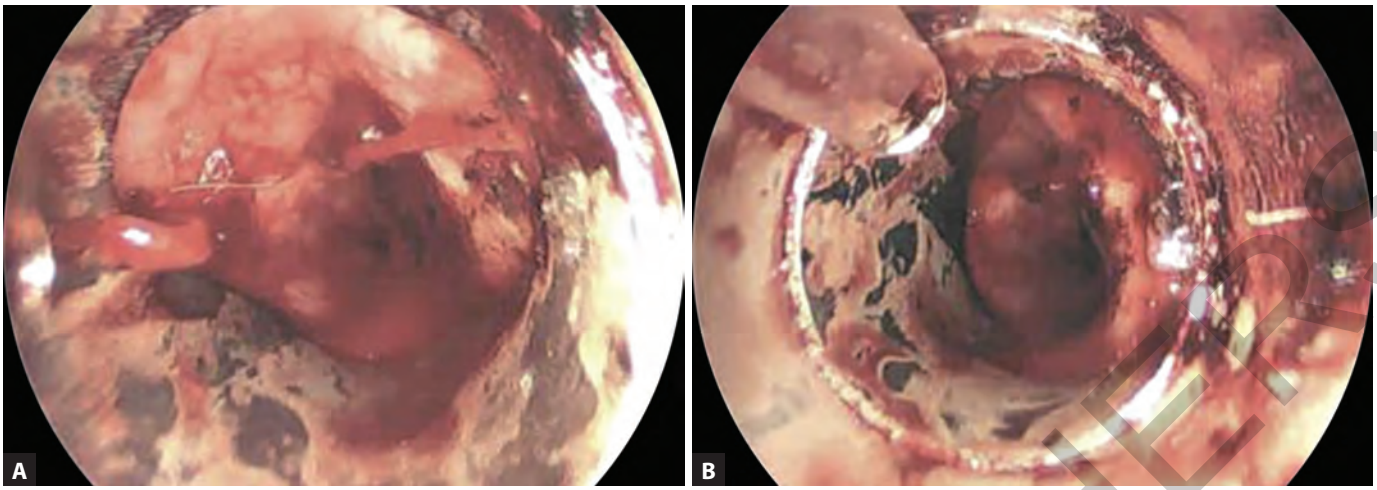
Bronchoscopy

Early bronchoscopy should be performed at bedside, which will facilitate direct visualization of the central airway thus allowing therapeutic intervention. These include injection of vasoactive agents, balloon and topical hemostatic tamponade and thermocoagulation.

- *Bronchial blocking techniques:* Bronchial blocking techniques are deployed in order to localize the bleeding site and prevent aspiration and contamination of the unaffected lung, thereby facilitating continued ventilation to the same. Moreover, it provides sufficient time to undertake therapeutic intervention.

  A bronchial blocker is a long flexible catheter of length 65–78 cm (4.5–9F) inserted through the endotracheal tube into the bleeding lung under Bronchoscopic guidance. They are usually placed in the

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Figs. 2A and B: (A) Submucosal tumor infiltration of bronchus intermedius isolated from the bevel of the rigid bronchoscope; (B) Simultaneous argon plasma coagulation therapy and suction of blood for airway clearance.

mainstem bronchus or the bronchus intermedius. It is a temporizing measure often in the first 48–72 hours, as it leads to atelectasis, pneumonia, compression trauma and necrosis of bronchial wall mucosa if kept in-situ for a longer duration.[20]

Several commercially available bronchial blockers such as Arndt blocker, Cohen Flexitip blocker, Fuji Uniblocker, and the EZ Blocker may be used.[21]

Balloon tamponade can also be achieved by means of other catheters such as Fogarty catheter inserted through the working channel of flexible bronchoscope.[22]

Rigid bronchoscopy provides a large lumen for passage of a large bore rigid suction which allows clearance of obstructive clots under direct visualization.

Compared to the therapeutic flexible bronchoscope, the large working channel of a rigid bronchoscope aids both suction and airway visualization simultaneously by facilitating passage of a rigid suction catheter, a small soft suction catheter and a flexible bronchoscope for both suction and airway visualization, simultaneously.

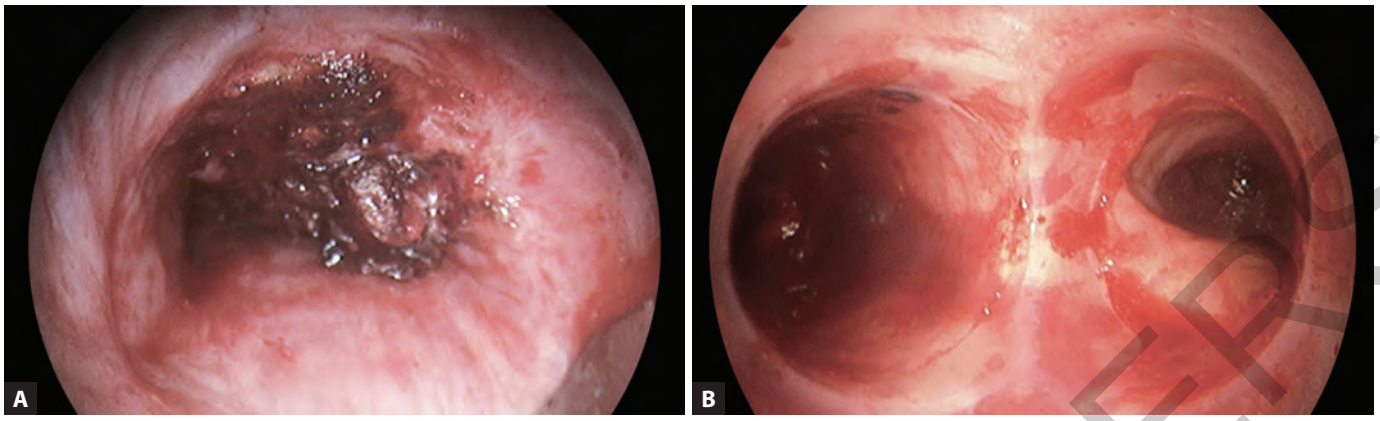
- Bronchoscopic interventions for control of bleeding
  - *Endobronchial medical therapy*
    - Ice cold saline irrigation[11]
    - Epinephrine and norepinephrine
    - *Antidiuretic hormone (ADH)-derivatives:* Terlipressin, Ornipressin
    - Bronchoscopic-guided topical hemostatic tamponade therapy using oxidized regenerated cellulose.
  - *Thermal ablative methods*
    - LASER Therapy: Nd:YAG (Neodymium yttrium aluminum garnet): The energy from laser beam is absorbed by tissues and converted to heat, thereby producing local effects by photocoagulation, vaporization and necrosis, respectively **(Figs. 2A and B)**[23,24]
    - Electrocauterization: Accomplished either by using noncontact method of conducting electrical energy through inert gas such as Argon (Argon Plasma photocoagulation) (Morice et al.)[25] or by using contact method of conducting electrical energy (electrocautery).[26] The tissue then converts the electrical energy to heat resulting in coagulation and necrosis.
  - *Endobronchial stents:* Silicone stents, with or without adjunctive endobronchial management modalities, are primarily being used for control of hemoptysis arising due to malignancies, especially when bronchial artery embolization fails. Number of case reports have proven the efficacy of this management strategy to be worthwhile in managing hemoptysis **(Figs. 3A and B).**[19,27]
  - *Brachytherapy and extrathoracic radiotherapy:* Brachytherapy was pioneered in the management of neoplasms, in 1920s, whereby a radioactive emitting substance, mounted on wire, used to be introduced via fiberoptic bronchoscope upto the proximity of the tumor, after adequate debulking, in order to accomplish the same. Although it was found to be efficacious in alleviating mild hemoptysis, its role in massive ones is limited.

In the past few decades, extrathoracic radiotherapy has shown to have moderate effect on hemoptysis, but substantially being palliative. Presently, its utility is guarded considering the recent day advancements.

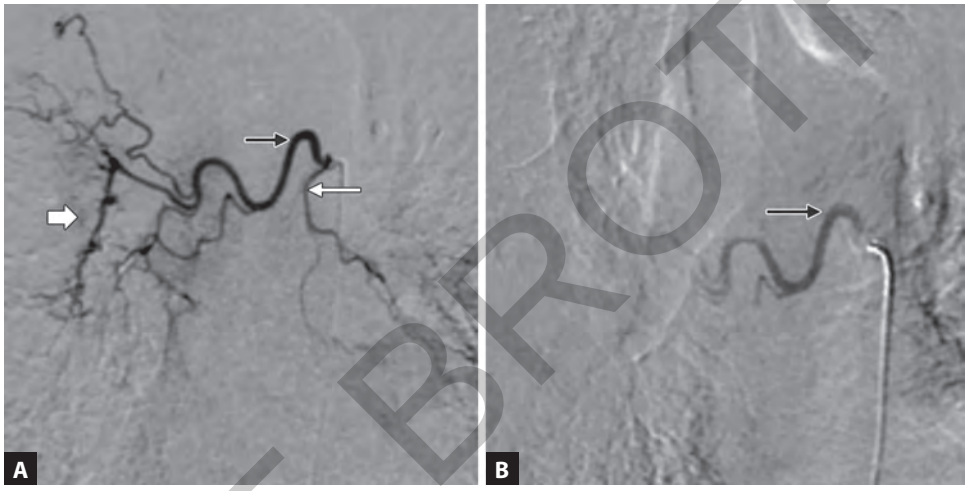
CT Chest

In hemodynamically stable patients, HRCT chest will give valuable information to localize the site of bleeding and thereby guiding bronchial artery embolization (BAE), if required. Bronchial artery embolization was first described by Remy et al., in 1974. Spinal cord ischemia results from embolization of anterior spinal arteries, which is considered to be the most feared complication of BAE.

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Figs. 3A and B: (A) Endobronchial bleeding tumor; (B) Tamponade effect obtained after stent placement following laser therapy and debulking.



Figs 4A and B: (A) Pre-embolization digital subtraction angiographic (DSA) image showing selective catheterization of common bronchial artery with hypertrophied right bronchial artery *(black arrow)* and left bronchial artery (*white arrow*) with parenchymal blush *(white block arrow)*; (B) Postembolization DSA image showing contrast stasis in right bronchial artery *(black arrow) with* obliterated left bronchial artery and no residual parenchymal blush suggestive of successful embolization.

Interventional Angiography

For those patients who are unable to tolerate bronchoscopy or surgery, bronchial artery embolization is the first line of therapy. Massive bleeding due to tuberculosis and bronchiectasis respond well to it. Complications may arise from non-target embolization, either to the esophagus resulting in dysphagia or to the spinal arteries resulting in transverse myelitis. Rare complications include dissection and arterial perforation.[1,11,28]

Bronchial Artery Embolization

The two most common indications of this in controlling hemoptysis are due to pulmonary tuberculosis and post tuberculosis sequelae such as fibrosis, aspergillosis and bronchiectasis.

Initially transfemoral arteriogram is performed followed by embolotherapy using any one of the following agents: gelatin sponge, polyvinyl alcohol (PVA) particles, microspheres, liquid embolic agents such as n-butyl-2-cyanoacrylate, and metallic coil.

Success rates of BAE in neoplasm related hemoptysis ranges from 60 to 90%.[29] Semi and Shimono evaluated results of a novel technique using chemotherapeutic agents such as cisplatin and fluorouracil, to infiltrate the feeding vessels of a neoplasm followed by embolization with gelatin sponge particles, whereby success rates reached 90% in alleviating hemoptysis **(Figs. 4A and B).**[30,31]

CONCLUSION

The diagnostic evaluation of patients with life-threatening hemoptysis remains focused on the localization of the leading site and underlying cause, which can be performed quickly with CT imaging in patients who have adequate oxygenation, ventilation, and are hemodynamically stable. Bronchoscopy remains invaluable for patients needing airway control and

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those in whom CT imaging cannot localize the bleeding site. The more widespread availability of bronchial artery embolization has led to a shift in the management of life-threatening hemoptysis.

Take Home Messages

- Try to establish that this is true hemoptysis and nothing else
- Identify the severity of hemoptysis.
- Detailed history taking and clinical examination might help to identify the cause.
- Appropriate investigations are essential to find out the site as well as the nature of lesions.
- Management includes basic resuscitation of patient, correction of blood loss, control of bleeding by applying modern technology and finally treatment of the cause of hemoptysis.

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