

NCCP TEXTBOOK OF RESPIRATORY MEDICINE

Under the Aegis of National College of Chest Physicians

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2 Chapter

Common Clinical Symptoms

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COUGH

Jai Kishan

DEFINITION

"Cough" (Latin: tussis) is a sudden and explosive forcing of air through glottis and often repetitively occurring reflex, which helps to clear the large breathing passages from secretions, irritants, foreign particles and microbes. Coughing is basically a reflex act arising from stimulation of cough or irritant receptors located in the pharynx, larynx, trachea and large bronchi. It can also be initiated and suppressed voluntarily. The cough reflex consists of three phases: An inhalation, a forced exhalation against a closed glottis and a violent release of air from the lungs following opening of the glottis, usually accompanied by a distinctive sound. Cough is one of the common symptoms of respiratory and nonrespiratory diseases for which the patient approaches a family physician. In case of pulmonary physicians, cough is the commonest symptom for which their consultation is sought by the patients.[1,2]

Cough serves the useful purpose of clearing the respiratory secretions and hence has a protective function. Cough at times can be troublesome when it is dry, paroxysmal, hacking, recurrent or without any expectoration. Cough depending upon the character and sound produced may be labeled as barking, wheezing, brassy or bovine.

PATHOPHYSIOLOGY

A cough is a protective reflex in healthy individuals that is influenced by psychological factors. The cough reflex is initiated by stimulation of two different classes of afferent nerves, namely the myelinated rapidly adapting receptors and nonmyelinated C-fibers with endings in the lungs. However, it is not certain that stimulation of nonmyelinated C-fibers leads to cough with a reflex as it's meant in physiology (with its own five components): This stimulation may cause mast cells degranulation and edema, which may work as a stimulus for rapidly adapting receptors.

"The afferent limb" includes receptors within the sensory distribution of the trigeminal, glossopharyngeal, superior laryngeal and vagus nerves.

"The efferent limb" includes recurrent laryngeal and spinal nerves.

The cough starts with a deep inspiration followed by glottic closure, relaxation of diaphragm, and muscle contraction against a closed glottis. The resulting marked positive intrathoracic pressure causes narrowing of trachea. Once the glottis opens, the large pressure differential between the airways and the atmosphere coupled with tracheal narrowing produces rapid flow rates through the trachea. The shearing forces that develop aid in the elimination of mucus and foreign materials.

CLASSIFICATION

Cough has been classified differently depending upon onset, duration, sputum production and periodicity Sudden onset of cough is seen in patients with his-tory of foreign body aspiration, infections, exposure to allergens or irritant gases or environmental pollutants.

Cough is termed as acute cough when the duration of cough is less than three weeks. A cough that has lasted for between 3 and 8 weeks is termed as "subacute cough". And coughing that has been going on for more than eight weeks is termed as "chronic cough". Some are of the view that cough of more than three weeks should be termed as chronic. If there is any cough of more than two weeks, then TB should be excluded in India as per RNTCP and International Standards of Tuberculosis Care and the patient should be subjected sputum smear examination for acid-fast bacilli. In about 85-90% of chronic cough patients, cough can be explained by postnasal drip, asthma, gastroesophageal reflux, bronchiectasis or eosinophilic bronchitis.[3,4]

Cough may also be classified depending upon its etiology like infection, inflammation, chemical or mechanical

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irritation, neoplasia, psychosocial, upper/lower respiratory causes, nonrespiratory causes or drug related.

Severity of cough may be classified as mild — occasional during the day and not awakening the patient at night, moderate — persistent during the day and occasionally awakening the patient at night and severe —paroxysms are uncontrollable and awaken the patient at night.

CAUSES

The most common causes of acute cough include: Common cold, acute sinusitis, tracheobronchitis, pertussis (whooping cough), COPD exacerbations, allergic rhinitis and nonallergic rhinitis. Less common, but more serious causes of acute cough include heart failure, pulmonary embolism, pneumonia and aspiration. Acute cough has also been divided into infectious and noninfectious causes.

Causes of subacute cough are: Postinfectious cough, acute sinusitis and asthma.

Causes of chronic cough are: Tumors, sarcoidosis or other lung diseases like ILD, carcinoma, etc.

Upper respiratory causes: Often relate to postnasal drip or caused by sinusitis, pharyngitis, rhinitis and rhinosinusitis. In children, concomitant otitis media and in adults, wax or hair in the external auditory canal should be considered.

Lower respiratory causes include originating from the lung (bronchitis, asthma, cough variant asthma, COPD, pneumonitis, lung abscess, bronchiectasis, neoplasia and interstitial lung diseases) and pleural diseases.

Nonrespiratory causes: More often than not, pericardial diseases, mitral stenosis, congestive heart failure and drugs like ACE inhibitors, β_2 blockers, anticancer drugs or immunosuppressants may be incriminated for causing cough. Gastroesophageal Reflux Disease (GERD) is also a common cause of cough. Smoking, although a very important cause of cough, is more often overlooked by patients as well as physicians.

Besides allergic, infective and noninfective causes, environmental pollution, occupational irritants, pulmonary embolism and abdominal processes that irritate the diaphragm may also cause cough. Cough can also be psychogenic or due to malingering.

Cough may have periodicity. Cough may be more in the early morning or at night. Early morning cough may be seen in asthmatics. Cough at night may be because of purulent disorders of the lung like lung abscess and bronchiectasis. It may be typically occurring past midnight in patients with left ventricular failure.

Patients with bronchial asthma and COPD may have seasonal variation of cough. Seasonal cough may also occur in viral infections like influenza.

Cough is usually taken as useful, if accompanied by expectoration but may be harmful, if dry.

Cough may cause several complications that include cough fracture, cough syncope,[5] cough-induced vomiting, pneumothorax, pneumomediastinum, costochondritis, surgical emphysema, subconjunctival hemorrhage, hernias, fatigue and urinary incontinence especially in females. Cough often causes exhaustion and insomnia.[6]

In males, cough headache is an entity where the patient develops headache on coughing which lasts for seconds to minutes. Often patients correlate headache with respiratory infection accompanied by severe coughing. Headache usually responds to indomethacin 50-200 mg daily. Arnold-Chiari malformation is a common cause of cough headache.[6] Cough syncope or tussive syncope results from paroxysm of coughing usually in men with bronchitis. After a severe bout of cough, the patient becomes weak and loses consciousness momentarily due to decreased venous return to the heart and brain because of raised intrathoracic pressure due to Valsalva's maneuver.[7]

Based on sputum production, there are two types of cough: Dry cough and productive cough

Dry Cough

- Dry and irritable cough: Early pulmonary TB
- Dry and Hacking cough: Chronic pharyngitis, laryngitis, tracheitis, neurosis
- Dry, nocturnal cough: Chronic pharyngitis, enlarged uvula
- Dry, reflex cough: Diaphragmatic irritation, peritonitis, gastritis

Productive Cough

Sputum produced in cough may vary in quantity, color, characteristics and periodicity and may have a typical taste and smell.

- ***Quantity:*** Sudden coughing of large amount of pus—Rupture of lung abscess, subphrenic abscess, empyema into bronchus.
- ***Appearance:***
  - *Yellow/purulent:* Infective
  - *Grayish/blackish:* Inhaled soot or dust
  - *Jet black:* Coalminers lung
  - *Pink frothy:* Pulmonary edema
  - *Redcurrant jelly:* Friedländer's pneumonia[1]
  - *Rusty:* Pneumococcal pneumonia
  - *Curschmann's spirals:* Asthma
- ***Postural variation:*** Bronchiectasis, lung abscess
- ***Smell:*** Foul smelling—Bronchiectasis, lung abscess, gangrene
- ***Foreign body:*** Hydatid, actinomycosis
- ***Hemoptysis:*** Post TB, trauma, cancer

SIGNS AND SYMPTOMS

Many causes of cough have overlapping signs and symptoms:

- If cough is related to environmental irritants, it will worsen when exposed to the offending agent and may improve when using antiallergy medications and avoiding the offending agent. Smoker's cough may improve on stopping smoking.
- In patients having diseases in bronchi or lung parenchyma, cough is usually deep and loose.
- Chronic lung diseases, such as asthma, emphysema or chronic bronchitis, present with persistent cough or cough that worsens with certain locations or activities.

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- Cough caused by chronic sinus infections, chronic runny nose or chronic postnasal drip will often have the signs and symptoms associated with these conditions.
- Cough associated with medications, such as Angiotensin-Converting Enzyme (ACE) inhibitors, will begin after starting the medication, is often dry and improves when medication is stopped.
- A cough associated with Gastroesophageal Reflux Disease (GERD) is often associated with a sensation of heartburn and worsens during the day on lying flat on back. Furthermore, few patients will note no symptoms of reflux, but most people will report improvement when GERD is treated properly.
- Postnasal Drip Syndrome (PNDS)[8] is one of the commonest causes of chronic cough. Here, cough is short, dry, hacking and frequently repeated.
- In lung cancer, there may be associated hemoptysis. Other signs and symptoms include worsening fatigue, loss of appetite, unexplained loss of weight, or decreased ability to swallow solid or liquid foods.
- A psychogenic cough ("habit cough" or "tic cough") may be the cause in the absence of a physical problem. In these instances emotional and psychological problems are suspected. However, other illnesses have to be ruled out before a firm diagnosis of psychogenic cough is made. Psychogenic cough is thought to be more common in children than in adults.
- Through irritation of the nerve, diseases of the external auditory canal (wax, for example) can also cause cough.
- Cardiovascular diseases associated with cough are heart failure, pulmonary infarction and aortic aneurysm.
- Coughing may also be used for social reasons, such as coughing before giving a speech.
- Coughing is not always involuntary; cough can be used voluntarily in social situations. Coughing can be used to attract attention, release internal psychological tension or become a maladaptive displacement behavior. It is believed that the frequency of such coughing increases in environments vulnerable to psychological tension and social conflict. In such environments, coughing may become one of many displacement behaviors and/or defense mechanisms.
- Acute onset of dry cough is associated with the acute stage of virus infections, bronchogenic carcinoma, early symptoms of left-sided heart failure, psychogenic cough in children or foreign body aspiration.
- Most acute dry cough, if sufficiently prolonged, eventually becomes productive.
- Acute cough with fever is usually because of viral infections causing tracheobronchitis.
- Stridor associated with cough is usually because of extrinsic or intrinsic compression of the upper respiratory tract.
- A persistent local wheeze during expiration often indicates an intrinsic bronchogenic lesion.[9,10]
- In children if cough is associated with fever but not breathlessness, most commonly it is due to viral upper respiratory infections but if breathlessness is present, then it is due to bronchiolitis.[11]

DIAGNOSTIC EVALUATION

History is one of the most important aspects of evaluation. It should address the following issues:[9]

- Is the cough acute or chronic?
- Is it associated with fever?
- Is it associated with wheeze?
- Is it associated with dyspnea?
- Is it associated with sputum? If so, what is its character, color, quantity, smell, taste and any relationship with posture?
- Is it seasonal or has a diurnal variation?
- Does the patient has important risk factors for cough like cigarette smoking, environmental exposure, occupational exposure, allergen exposure, homosexuality, intravenous drug use or immobilization?
- What is the past medical history?
- What is the character of cough: Barking, brassy, whooping or bovine?
- Is it associated with blood? If yes, whether it is blood streaking of the sputum, mixing of sputum with blood, pure blood or pink frothy sputum, rust sputum, current jelly sputum or anchovy sauce appearance.
- What are the aggravating/relieving factors?[7]

In addition to the above, associated signs and symptoms and history of foreign body inhalation, smoking, infections, postnasal drip, throat irritation, breathlessness, drug intake and gastric reflux need to be elicited. Female patients often do not give the history of cough or expectoration of sputum. Females usually swallow sputum. So, the history of cough should be specifically asked and evaluated in females.

WORK UP OF PATIENTS OF ACUTE COUGH

Signs and symptoms that point to an infection include fever, chills, body ache, sore throat, nausea, vomiting, headache, sinus pressure, runny nose, night sweats and postnasal drip. Sputum or phlegm sometimes indicates an infection is present, but it is also seen in noninfectious causes.

Signs and symptoms that point to a noninfectious cause include cough that occurs when you are exposed to certain chemicals or irritants in the environment, cough with wheezing, cough that routinely worsens when you go to certain locations or do certain activities, or cough that improves with inhalers or allergy medications.

If a patient is having duration of cough of less than 3 weeks but has no history of dyspnea or tachycardia or fever is less than 38° C and there are no physical signs of consolidation or crackles, then most likely it is due to influenza.

But if a patient is having dyspnea, tachycardia (HR >100), tachypnea (RR >24/min) and there are signs of consolidation or crackles, then X-ray chest should be undertaken. If X-ray is within the normal limits, then the patient should be given symptomatic treatment and in case symptoms persist for 24 hours, repeat X-ray especially after proper hydration should be done. On proper hydration, X-ray may reveal consolidation but if the X-ray is abnormal then diagnosis of bacterial, tubercular, fungal infections or PCP should be considered.

In children, the sudden onset of cough with recurrent cough thereafter leading to nonresolving pneumonia or

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recurrent pneumonia at the same site may be due to foreign body aspiration.

In children, hacking, brassy, barking, paroxysmal cough followed by long and deep noisy inspiration, i.e. whoop may be due to whooping cough. In children, cough with stridor may be due to laryngeal webs or laryngitis. History of cough on taking feed in newborn may be due to tracheobronchial fistula.

Acute cough with fever and cough in adults is due to common cold, sinusitis, bronchitis, influenza and pneumonia, which include community-acquired pneumonia, tuberculosis and opportunistic infections like PCP, but in an endemic setting, influenza, SARS, swine flu, etc. may be considered if there is history of contact with the patient who is a confirmed case of SARS or swine flu during endemic spread.[12]

WORK UP OF PATIENTS OF CHRONIC COUGH

Physical examination[13] of ear, nose, throat, sinuses and vocal cords, auscultation of chest and even examination of abdomen may give clues to the causes of cough.

Radiological examination of sinuses and chest, spirometry of lung including reversibility test, methacholine allergen challenge test, 24-hour ambulatory esophageal pH monitoring and bronchoscopy may also give the diagnostic clue to the etiology of cough.

Any change in the character of cough may be due to infection or neoplasia.[14]

General physical examination and nonpulmonary systems examination may often give a clue to malignancy or connective tissue disorders, which often cause symptoms of chronic dry cough. Careful history alone can give a clue to the etiology of cough in more than 70% cases.

Smokers as such are taking cough due to smoking and often tend to ignore the symptoms of cough, same is with physicians also. In a patient who is a smoker, if cough becomes persistent or worsens with change in character or is accompanied by purulent expectoration, hemoptysis or there is appearance of constitutional symptoms, such as fever, anorexia and weight loss, then inflammatory processes or malignancy should be suspected. Pseudohemoptysis occurring from nose, oropharynx and buccal cavity, including gums and dental caries, needs to be evaluated by careful examination of these areas.

In India, pulmonary tuberculosis and bronchitis are the common causes of cough with hemoptysis.

Nonrespiratory diseases like PNDS, pulmonary venous hypertension, mitral stenosis, left ventricular failure and GERD are often the common causes of chronic cough and need to be carefully evaluated and excluded.

Irwin et al (1998)[15] has given a diagnostic algorithm of chronic cough. In a patient having cough of more than three weeks duration, if the patient is on ACE inhibitors or beta-blockers, stoppage of these drugs will lead to relief in the symptoms of cough. In case cough is not relieved, then X-ray chest of the patient should be undertaken. If X-ray is normal and avoidance of irritants and smoking cessation don't relieve the symptoms of cough, then PNDS, GERD and asthma are common causes. On careful exclusion of patients for PNDS, GERD and asthma, uncommon cause of chronic cough by sputum examination, HRCT scan, Barium esophagography, bronchoscopy and cardiac studies should be undertaken. In case X-ray of the patient with chronic cough is abnormal, the patient should undergo sputum examination, HRCT scan, bronchoscopy or other specific investigation. Cough due to GERD can be diagnosed on 24-hour ambulatory esophageal pH monitoring, which besides quantifying the amount of reflux also shows a temporal relation between the cough and reflux.[16]

Careful evaluation of the quantity, color, characteristic, taste and smell of expectoration can give a clue to the etiology of cough. Clear and mucoid sputum is usually seen in smokers, patients of chronic bronchitis and COPD without infection. Copious watery sputum is seen in patients with alveolar cell carcinoma.

In a patient having ruptured hydatid and cough with sputum production, sputum is clear and watery and at the same time, salty in taste.

Purulent sputum is because of COPD exacerbation and pneumonia. Cough with massive expectoration, which is often having postural relationship and putrid smell, is seen in bronchiectasis, lung abscess, hydropneumothorax and empyema with bronchopleural fistula and is mostly due to anaerobic infections. Greenish discoloration is observed in patients having *Pseudomonas aeruginosa* infection. Rusty sputum is observed in resolving pneumonia. Golden yellow sputum is characteristic of biliary tract bronchial fistula.[17]

Brassy cough is often due to growth but unusually, it may be because of aortic aneurysm. Bovine cough is indicative of laryngeal nerve palsy which besides neoplasia may be due to aneurysm of aorta, pericardial effusion and mitral stenosis.

Spirometry is often helpful in telling restrictive or obstructive cause of cough. Methacholine test is sometimes useful in diagnosing cough variant asthma as a cause of cough in the presence of normal spirometry. Bronchial provocation test may help in finding out the allergen or occupational cause of cough.

During endemicity, swine flu or SARS may be taken as a cause of cough when typical history of contact with the patient of proven endemic disease is elicitable. Wax or hair may be the sole cause of chronic cough.

PREVENTION

Preventive measures include smoking cessation, allergen avoidance, environmental protection, health and lifestyle modification, pollutants avoidance, weight reduction and pneumococcal vaccines in the elderly. Smoking cessation in a smoker is one important modality for preventing cough.[18]

MANAGEMENT

Definitive treatment of cough depends on determining its precise cause and then initiating specific treatment for the underlying cause. When this is done specific therapy is usually effective. When specific cause for cough is not

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known or when cough is dry, irritating, troublesome and disturbs the normal routine and sleep, then symptomatic or nonspecific therapy of cough is considered. Dry, irritative, nonproductive cough causing discomfort may be suppressed by antitussive agents, which increase the latency or threshold of cough center. Most commonly used agents are codeine (15 mg QID) and dextromethorphan (15 mg QID). Many a times, these drugs are abused because of their central actions. Since, cough is a protective defense mechanism of the body, so a cough productive of significant quantities of sputum should usually not to be suppressed. Retention of secretions, besides interfering with ventilation, impairs alveolar aeration and may further aggravate infection because of stagnation of secretions. Removal of secretions can be helped by postural drainage depending upon the site and side involved in patients of lung abscess and bronchiectasis. Thick tenacious secretions may be got rid of by adequate hydration and humidification of air with an ultrasonic nebulizer with ipratropium and 3% sodium chloride. Iodinated glycerol (30 mg QID) and guaifenesin (100 mg TID) are available which can be given to patients of asthma and bronchitis. Xanthine derivative (theophylline 100 mg TID) may be helpful by way of its bronchodilator and anti-inflammatory properties.

It will be wise to use cough suppressants if the patient is also having hemoptysis.

Antihistamines are mostly used for the treatment of cough, although they are not very effective in children and expose them to the danger of seizures if given in toxic amounts.[19]

Morphine and related opioids also depress the cough reflex, at least in part by a direct effect on the cough center in medulla. Obligatory relationship between the depression of cough and depression of respiratory center is not seen. Effective antitussives are available which do not suppress respiration.[20]

Ten to twenty milligram of codeine, although ineffective for analgesia, produces cough suppression. Codeine and hydrocodeine act as antitussive because of their central action and so are likely to be abused. β_2 adrenergic agonists suppress cough in asthmatics without having Central Nervous System (CNS) effect.[20]

Dextromethorphan 10–30 mg 3–6 times daily acts centrally to elevate the threshold for coughing and is as effective as codeine.

Levopropoxyphene napsylate 50–100 mg orally is another useful antitussive. Noscapine is a potent antitussive with no significant action on the CNS, however high doses may cause bronchoconstriction and hypotension. Pholcodeine, Carbetapentane, Caramiphen, Chlophedianol, diphenyhydramine and glaucine are also antitussives.

Benzonatate exerts antitussives action by action on stretch or cough receptors on the lungs, as well as by a central mechanism in oral doses of 100 mg thrice daily. Many cough preparations also contain an expectorant. The combination of cough suppressant and an expectorant in one preparation is beyond comprehension.[19]

Topical sympathomimetics used as nasal decongestants may get absorbed systematically resulting in tachycardia, raised blood pressure, irritability, insomnia and even frank psychosis because of CNS stimulation. Risk of using decongestants outweighs any potential benefits.[17]

SPECIFIC TREATMENT OF CAUSE

Asthma

Inhaled bronchodilators, inhaled steroids and oral steroids are useful. In case of cough variant asthma-inhaled steroids, alone or in combination with long-acting β_2 agents are effective.

Gastroesophageal Reflux Disease (GERD)

Avoiding foods that increase reflux, avoiding meals before lying down, stopping smoking, elevating the head while sleeping and weight reduction are important. H2 blockers and proton pump inhibitors are the mainstay of cough due to GERD.

Sinus Problems and Postnasal Drip

Use of decongestants, such as pseudoephedrine or antihistamines such as diphenhydramine, may improve the symptoms of postnasal drip. Antibiotics may be prescribed if the cause is determined to be sinusitis. Cough due to PNDS is best managed by older-generation antihistamines, if because of vasomotor or postinfectious rhinitis. Newer generation antihistamines, even when combined with ipratropium, are the poor controllers of cough rhinitis. In PNDS due to allergic rhinitis, nasal steroids are the drugs of choice but saline nasal wash[21] and nasal cromolyn are also effective.

Infections

Bacterial pneumonia and bronchitis are typically treated with antibiotics. In pleurisy, analgesics can be helpful.

Most bronchitis in adults is from virus infection; therefore, treatment is much the same as that of the common cold including rest, fluids, analgesics and humidification. Some people find expectorant cough medicines containing guaifenesin helpful in alleviating their discomfort.

Medications

Angiotensin receptor blockers (ARBs), e.g. valsartan, losartan, etc. can be alternatives for ACE inhibitors.

Severe cough or cough that interferes with sleep may need remedies that include narcotic medications. If these are prescribed, take care to avoid alcohol, driving and operating any heavy machinery while using the medication.

Amiloride aerosol therapy can be useful in patients of cystic fibrosis.

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HEMOPTYSIS

SK Katiyar, Arun Sampath

Hemoptysis, defined as expectoration of blood originating from the lungs or tracheobronchial tree, is one of the major symptoms of cardiopulmonary diseases.[1] It may vary from streaking of blood in sputum to massive or life-threatening hemoptysis. The lungs receive blood from the pulmonary and bronchial arterial systems. The vast majority of hemoptysis events originate from the bronchial arteries (90%) as compared with the pulmonary arteries (5%).[2] The low-pressure pulmonary system tends to produce small-volume hemoptysis, whereas bleeding from the bronchial system, which is at systemic pressure, tends to be profuse.[3] The definition of massive hemoptysis varies from 200 ml–1,000 ml/24 hours in the literature,[4,5] but most authors adopt 600 ml to define massive hemoptysis. Severe hypoxemia may occur with the presence of only 400 ml of blood in the alveolar space.[6] Hemoptysis is massive in only 1.5% of cases.[7] Quantification of blood loss can be challenging. The amount of blood expectorated tends to be exaggerated by the patient, whereas the volume of blood engulfing the affected lobes, although significant, can be underestimated and/or is unmeasurable. The amount of bleeding does not influence the need for full investigation, since the quantity of blood may not be correlated with the seriousness of the underlying thoracic disease.[1,8,9]

CLINICAL ASSESSMENT

Bleeding from other than lower respiratory tract that mimics hemoptysis must be first differentiated by clinical history and examination. Blood from the lower respiratory tract typically induces cough, whereas a history of epistaxis or expectorating without cough would be consistent with an upper respiratory source but does not exclude a lower tract site. When the bleeding is suspected to originate from the nasopharyngeal space, nasal and laryngoscopic exploration should be done. An additional consideration is distinguishing hemoptysis from hematemesis because both are treated in different manner. There are some diagnostic clues that help to distinguish between hemoptysis and hematemesis. Blood that originates in the airways is usually bright red, is mixed with frothy sputum, has an alkaline pH and contains alveolar macrophages that are laden with hemosiderin. In contrast, blood from the stomach is usually dark, has an acidic pH, contains food particles and often occurs in patients with a long history of gastric complaints. However, in some patients it will be difficult to differentiate hemoptysis from pseudohemoptysis and extensive investigations may be required.

A detailed clinical history must be elicited in all cases. Factors such as age, smoking history, duration and frequency of hemoptysis, comorbid conditions and associated symptoms can aid in the differential diagnosis. It is helpful to determine whether there have been previous episodes of hemoptysis and what diagnostic assessments have been done. Mild hemoptysis recurring sporadically over a few years is common in smokers who have chronic bronchitis punctuated with superimposed acute bronchitis. Chronic obstructive pulmonary disease is also an independent risk factor for hemoptysis. Smokers older than 40 years must be evaluated for lung cancer.[10] Patients previously diagnosed with tuberculosis may bleed from the leaky dilated blood vessel in the cavity wall.[11] A history of chronic, copious purulent sputum production and frequent pneumonias may represent bronchiectasis. Bronchial adenomas, although malignant, are slow growing and may present with occasional bleeding over many years. Environmental exposure to asbestos, arsenic, chromium, nickel and certain ethers increases risk for hemoptysis. Association of hemoptysis with menstruation (i.e. catamenial hemoptysis) may represent intrathoracic endometriosis.[12] Also biologic weapons, such as plague, anthrax, tularemia and smallpox, may cause hemoptysis.[13,14] They may cause hemoptysis either by direct lung involvement or by hemorrhagic complications, especially disseminated intravascular coagulopathy.

SIGNS AND SYMPTOMS

Mild hemoptysis is not usually associated with dyspnea except when the underlying conditions are associated with hypoxemia, pulmonary venous congestion (severe mitral stenosis, left ventricular failure), pulmonary embolism, extensive parenchymal infiltrates.[15] However, patients with massive hemoptysis exhibit moderate to severe dyspnea due to aspiration of blood in to tracheobronchial tree and reduced alveolar gas exchange. Chest pain is cardinal symptom in dissecting aneurysm, pulmonary embolism and infarction.[16] Pleuritic chest pain may also be present in patients with necrotizing pneumonias. Presence of fever may indicate the infective cause for hemoptysis, but vasculitis, neoplasm and pulmonary embolism may also manifest with fever. Weight loss suggests tuberculosis, HIV, lung cancer and chronic suppurative conditions like bronchiectasis. Hemoptysis associated with bloody/ dark brown urine may suggest vasculitis or blood dyscrasia.

A detailed clinical examination must be made which include documenting fever, tachypnea, tachycardia, body weight and pulse oximetry. The skin and mucus membranes should be inspected for cyanosis, pallor, ecchymosis, telangiectasia, gingivitis or evidence of bleeding from the oral or nasal mucosa. Extremities must be inspected for clubbing and edema. The examination for lymph node enlargement should include the neck, supraclavicular region and axillae. The cardiovascular examination includes an evaluation for jugular venous distention, abnormal heart sounds and edema. Lung examination findings such as rales or wheezing are usually nonspecific and represent the under-

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lying condition.[3,17] Examining the expectoration may help in differentiating hemoptysis from hematemesis.[3,13] Some clinical clues are helpful in the differential diagnosis. Clubbing should raise the possibility of lung cancer or chronic suppurative lung diseases. A rumbling diastolic murmur over the apex may suggest mitral stenosis. Blood dyscrasia must be suspected, if cutaneous purpura or ecchymosis is present. Malnutrition or cachexia suggests tuberculosis, HIV and lung cancer. The coexistence of rhinitis, nasal septal perforation and saddle nose in a patient with hemoptysis should heighten the suspicion of Wegener's granulomatosis.[18] Hemoptysis in an otherwise healthy child should evoke the possibility of foreign body aspiration.

CAUSES

The common causes of hemoptysis are acute and chronic bronchitis, pneumonia, tuberculosis, and lung cancer (Table 2.1).

Table 2.1: Causes of hemoptysis

S. No	Causes
1	Neoplasms • Bronchogenic carcinoma • Bronchial adenoma • Bronchial carcinoid • Kaposi sarcoma • Endobronchial metastasis
2	Infective • Pulmonary tuberculosis • Acute and chronic bronchitis • Bronchiectasis • Lung abscess • Pneumonia • Fungal and parasitic infections of lung
3	Pulmonary Vasculitis • Good Pasteur's syndrome • Wegner's granulomatosis • Behcet's disease • Systemic lupus erythematosus
4	Vascular etiologies • Left ventricular failure • Mitral stenosis • Pulmonary infarct or embolism • Pulmonary veno-occlusive disease • AV malformations • Rupture of thoracic aneurysm • Iatrogenic rupture of pulmonary artery by Swan-Ganz catheter
5	Trauma • Blunt or penetrating lung injury • Foreign body aspiration • Lung biopsies
6	Rare pulmonary causes • Pulmonary amyloidosis • Idiopathic pulmonary hemosiderosis • Lymphangioleiomyomatosis • Broncholiths • Pulmonary endometriosis (catamenial hemoptysis) • Bronchial cysts • Pulmonary sequestration
7	Miscellaneous • Bleeding diathesis (hemophilia, vonWillebrand's disease, thrombocytopenia) • Anticoagulant therapy • Munchausen syndrome

Infection

Infection is the most common cause of hemoptysis, accounting for 60–70% of cases.[19] Pulmonary tuberculosis is an important cause of hemoptysis in India and other developing countries. Hemoptysis frequently occurs in pneumonia caused by invasive bacteria (e.g. *Staphylococcus aureus, Klebsiella, Pseudomonas aeruginosa*). Viruses, such as influenza, may also cause severe hemoptysis.[20] The infecting organism determines the appearance and composition of the material that is expectorated with the blood. The sputum is characteristically rusty looking in pneumococcal pneumonia, but sometimes it is faintly or grossly bloody. In Staphylococcal pneumonia, the blood is mixed with pus. In Klebsiella pneumonia, the bloody sputum often resembles currant jelly. Brisk bleeding is common in lung abscess. The blood is mixed with copious amounts of foul smelling pus. In lung gangrene, blood is associated with necrotic lung tissue.

Hemoptysis usually occurs in active tuberculosis. However, it may occur years after the disease has been adequately treated, from any of the bronchopulmonary sequelae of previous tuberculous infection, including broncholithiasis, bronchiectasis, a residual cavity with or without a mycetoma and scar carcinoma.[21] Bleeding from a tuberculous cavity, whether the infection is active or arrested, has been attributed to rupture of a Rasmussen aneurysm, a pear-shaped dilatation of a pulmonary or bronchial artery in the wall of the cavity.[22] However, in a study on 138 patients with tuberculosis dying of pulmonary hemorrhage, only eight instances of aneurysmal dilatation of arteries lining the blood-filled tuberculous cavity were found.[23] Rather than being due to distinct aneurysmal dilatation of a bronchial or pulmonary artery, hemoptysis is more likely related to the development of a hypervascularized, dilated, tortuous bronchial circulation and to anastamosis between the bronchial and pulmonary circulations. The same mechanism occurs in hemoptysis of patients with bronchiectasis, cystic fibrosis and lung abscess.[24–27] Bleeding from a mycetoma is due to friction caused by movement of the mycetoma, and release of an anticoagulant and trypsin-like proteolytic enzyme from the fungus.[28] Hemoptysis in patients with amebic lung abscess resembles anchovy sauce. Hydatid cyst and paragonimiasis are the parasitic diseases that may cause hemoptysis.

Lung Cancer

Bronchogenic carcinoma is a common lung cancer responsible for hemoptysis in 5–44% of all cases. The likelihood of a neoplastic cause of hemoptysis is greatly increased in a cigarette smoker. Usually a troublesome cough and vague chest pain precede and accompany the hemoptysis. For hemoptysis to occur, the lesion must communicate with the airways. In cases of bronchogenic carcinoma, pathologic studies have shown an increase in the bronchial arterial supply to the region of the tumor.[25] However, the abnormalities in bronchial circulation were shown to be present in 3% of cases with lung carcinoma. It is unlikely that hemoptysis in patients with bronchogenic carcinoma is due to the rupture of large

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bronchial arteries or bronchopulmonary anastomosis, since hemorrhage in these patients is usually mild and rarely massive. Malignant tumors of the lung more likely produce hemoptysis by invasion of the mucosa or by necrosis of tumor tissue. Obstructive lesions may cause a secondary infection, resulting in hemoptysis. Hemoptysis is uncommon in metastatic lung cancers. Some of the benign lesions like adenoma and carcinoid can lead to hemoptysis and may be difficult to manage.

Cardiovascular Causes

Pulmonary venous hypertension can produce hemoptysis due to pulmonary congestion and alveolar edema. The most common causes are left ventricular failure and mitral stenosis. Tight mitral stenosis is sometimes first manifested by a bout of brisk, bright-red hemoptysis that is difficult to control. The source of the bleeding is the submucosal bronchial veins, which proliferate considerably in this disorder. In chronic pulmonary congestion due to any cause, hemosiderin laden alveolar macrophages are found in the sputum. Pulmonary thromboembolism can produce hemoptysis when associated with infarction. The hemoptysis of pulmonary infarction is usually associated with pleuritic pain and often with a small pleural effusion because of the peripheral location of the infarct. However, pulmonary embolism is an uncommon cause of hemoptysis. For example, in a patient without underlying cardiopulmonary disease, the positive and negative likelihood ratios for hemoptysis in pulmonary embolism are 1.6 and 0.95, respectively. Therefore, the presence or absence of hemoptysis alone has no significant effect on the likelihood of pulmonary embolism.[29] Hemoptysis from other circulatory disorders is much less common. Occasionally, rupture of thoracic aortic aneurysm or pulmonary arteriovenous fistula into airways can lead to torrential bleeding that may be difficult to arrest.

Trauma

Hemoptysis associated with closed chest trauma is usually due to contusion of the lung parenchyma, i.e. exudation of blood and edema fluid into the intra-alveolar spaces as well as interstitium.[30] Direct penetrating injuries by stab or gun shot can tear the lungs or airways leading to either hemoptysis or hemopneumothorax. Iatrogenic causes of hemoptysis include bronchoscopy, lung biopsy (either transthoracic or transbronchial), rupture of pulmonary artery by the tip of Swan-Ganz catheter. After pneumonectomy or lobectomy, a large hemothorax occasionally empties into the airways. This is an alarming and ominous event. The hemothorax must be promptly evacuated and the bronchus is surgically repaired. An aspirated foreign body produces bleeding by damaging the mucosa on impact and if allowed to remain in place, it sometimes causes bronchiectasis, which in turn may cause bleeding. On occasion, mucosal lacerations in the course of severe coughing due to any cause can evoke hemoptysis.

Miscellaneous

There are many other rare causes of hemoptysis. They vary greatly in severity, urgency and prognosis. Pulmonary calcific foci, either in the pulmonary parenchyma or in lymph nodes may erode into the bronchus (broncholiths) and can cause hemoptysis. Blood dyscrasias, notably thrombocytopenic purpura and hemophilia and the therapeutic use of anticoagulants are occasional causes of hemoptysis. Very rarely, hemoptysis occurs during menstruation ("catamenial hemoptysis") due to pulmonary endometriosis. Hemorrhage in Goodpasture's syndrome is due to abnormalities in the alveolocapillary basement membrane due to antibody directed to the membrane. In 7–34% of patients with hemoptysis, no identifiable cause (idiopathic hemoptysis) can be found after careful evaluation.[31–33] Prognosis for idiopathic hemoptysis usually is good and the majority of patients have resolution of bleeding within six months of evaluation.[34] However, in smokers older than 40 years with idiopathic hemoptysis, the diagnosis of lung cancer was made later in significant number of cases and hence, close follow-up of them is warranted.[33]

DIAGNOSTIC APPROACH

A careful history and physical examination throws light on some of the diagnostic clues as described above. Chest radiograph is the initial investigation for evaluation of hemoptysis. The characteristics of the lung pathology (e.g. cavities, infiltrates or tumors) and the site involved can be recognized on a plain chest X-ray. However, it should be cautioned that intra -alveolar hemorrhage may mimic an infiltrate and may obscure the underlying pathology and mislead the site of bleeding. In about 20–46% of cases, chest X-ray may be normal.[35] Initial studies also include a complete blood count and coagulation profile which may show the degree of anemia and any blood dyscrasia. Sputum must be collected and be evaluated by Gram and Ziehl-Neelsen stain. Staining and culture for fungus are necessary in suspected mycetoma cases. Studies of renal function and a urinanalysis may be indicated when there is high possibility of systemic vasculitis (e.g. Goodpasture's syndrome).

If the diagnosis remains unclear after initial evaluation, then CT scan of chest or bronchoscopy may be warranted. The choice between these two still remains controversial. In high-risk patients with a normal chest radiograph, fiberoptic bronchoscopy should be considered to rule out malignancy. Risk factors that increase the likelihood of finding lung cancer on bronchoscopy include male sex, older than 40 years, a smoking history of more than 40 pack-years and duration of hemoptysis for more than one week.[36] Fiberoptic bronchoscopy is preferred, if neoplasia is suspected. It is diagnostic for central endobronchial disease and allows for direct visualization of the bleeding site. It also permits tissue biopsy, bronchial lavage or brushings for pathologic diagnosis. Fiberoptic bronchoscopy also can provide direct therapy in cases of continued bleeding. Rigid bronchoscopy is the preferred tool for cases of massive bleeding because of its greater suctioning and airway maintenance capabilities.

High-resolution CT scan is preferred, if parenchymal disease is suspected. CT scan chest is very sensitive in the diagnosis of bronchiectasis, small tumors, vascular pathologies, pulmonary embolism and bronchoarterial fistula.[37] The prevalence of bronchogenic carci-

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Table 2.2: Treatment of massive hemoptysis

S. No	Treatment modalities
1	Medical management • Bed rest (lying down on same side of bleeding) • Blood (or blood products) transfusion • Sedatives/anxiolytics • Cough suppressants (antitussives) • Oxygen supplementation • Reversal of anticoagulation • Broad spectrum antibiotics • Anti-tuberculosis drugs (in PTB patients) • Nonspecific coagulants (tranexamic acid, etc.) • Corticosteroids (immunologic diseases) • GnRH analogs (pulmonary endometriosis)
2	Control of bleeding • Endobronchial measures – Ice cold saline lavage – Balloon tamponade (Fogarty, Marisco blocker) – Pulmonary isolation (selective intubation) – Tamponade with vasoconstrictive substances – Selective coagulative treatment – Laser photocoagulation – Electrocautery • Bronchial artery embolization – Polyvinyl Alcohol (PVA) – Gelatin sponge/gelfoam – Tris-acryl gelatine microspheres – Gianturco coils – Interlocking Detachable Coil (IDC) – Superselective bronchial artery embolization (ssBAE) • Other measures – Radiotherapy – Positive end expiratory pressure (PEEP) – Lung abscess drainage – Pneumoperitoneum/Pneumothorax – IV vasoactive drugs
3	Surgical therapies • Pulmonary resection (pneumonectomy/lobectomy/segmentectomy) • Intrathoracic vascular ligatures • Collapse therapy (thoracoplasty) • Cavernostomies

noma in patients with either a normal or nonlocalizing chest radiograph is extremely low (5%) and the prognosis is good with an insignificant proportion developing cancer when followed up. For these reasons, attention has been paid to the role that CT can play as an adjunct or alternative to bronchoscopy. Several studies have shown a greater yield of bronchoscopic biopsy, if CT scan was done prior to bronchoscopy.[32,38,39] It is useful for excluding malignancy in high-risk patients.[40] Despite the high sensitivity of CT scan, the cause for hemoptysis remains unknown in 5–10% of patients.[32] In practice, HRCT and bronchoscopy are often complementary for visualizing abnormalities that are not apparent on plain chest radiographs. Patients with chronic bronchitis and at low risk for malignancy, or in whom the chest radiograph is normal or identifies the cause of hemoptysis (e.g. epistaxis or pneumonia) can usually be treated initially for bronchitis with follow-up appraisals to show prompt resolution of hemoptysis. However, should hemoptysis recur, further evaluation is required.

MANAGEMENT

There are three important goals of management of patients with hemoptysis; prevention of asphyxiation, bleeding cessation and treatment of underlying cause. The intensity of management depends upon the severity of hemoptysis (nonmassive versus massive). Majority of the patients present with mild hemoptysis often due to acute bronchitis. These low-risk patients mostly with normal chest radiographs can be treated on an outpatient basis with close monitoring and appropriate oral antibiotics, if clinically indicated.

Massive hemoptysis is a life-threatening condition that requires prompt intervention. Various definitions of massive hemoptysis that have been proposed have been based on the volume of blood expectorated, ranging from 100 ml in 24 hours to more than 1000 ml in 24 hours[41,42] or on the magnitude of the effect of expectorated blood on the patient's clinical status.[43–45] According to the latter criteria, massive hemoptysis can be defined as any volume of expectorated blood that is life-threatening by virtue of airway obstruction, hypotension or blood loss. The most important factors influencing mortality in this life-threatening complication are the rate of bleeding and the ability of the patient to maintain a patent airway.[46,47] The volume of blood loss may be underestimated since a significant amount may remain in the lung and may not be expectorated. The term "life-threatening hemoptysis" denotes any one of the following: expectoration of at least 250 ml blood per day; requirement for blood transfusion, failure of conservative management of hemoptysis or posing serious threat to life.[48] Hemoptysis may be life threatening and has propensity to recur if definitive therapy is not given. In a study, about 36% of patients with massive hemoptysis who were treated with medical therapy alone had recurrent episode of hemoptysis within six months.[44] Out of them 45% recurrent episodes proved fatal.

MEDICAL THERAPY

The initial management of any patient with massive hemoptysis must aim torwards stabilizing ABC (Airway, Breathing, Circulation) (Table 2.2). If the patient is asphyxiated due to hemoptysis, immediate endotracheal intubation must be done to protect airways and for ventilation. For others, position the patient in bed with the head lower than the chest and the side of bleeding dependant to prevent asphyxiation and aspiration. Two wide bore intravenous cannula must be inserted and fluids given to maintain intravascular volume. Blood transfusions may be required to keep hematocrit above 30%, but excessive transfusion to raise the blood pressure may actually promote bleeding. Mild doses of sedatives (diazepam or midazolam) and antitussives (codeine) can be used to quieten the patient. Excessive sedation and suppression of coughing must be avoided to prevent aspiration. Arterial blood gas must be monitored and if PaO_2 is less than 60 mmHg, then oxygen supplementation is necessary. Broad-spectrum antimicrobials may be considered,

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if there is a high likelihood of infection or to reduce the incidence of pneumonia due to aspiration. In patients with pulmonary tuberculosis, prompt initiation of anti-tubercular drugs, which are likely to be sensitive, reduces the mortality and morbidity rate. Bronchodilators should not be given unless associated with bronchospasm or COPD, as they have vasodilator actions and might increase bleeding. Patients with catamenial hemoptysis would benefit from treatment with Danazol or GnRH analogs like Leuprolide.[49]

ENDOBRONCHIAL CONTROL MEASURES

These measures may be combined with either medical or surgical management and they buy time for the restoration of clinical stability and performance of essential diagnostic and management procedures.

Ice-Cold Saline Lavage

Bronchial vessels respond to cold by vasoconstriction similar to peripheral blood vessels. This technique requires rigid bronchoscopy. After the bleeding site is identified, 50 ml aliquots of iced saline are injected and allowed to remain in contact for 15 seconds and then suctioned out. More than one liter of cold saline may be used and this method reliably stops bleeding in 95% cases. After two days, rigid or flexible bronchoscopy is repeated to remove the blood clots and to identify the cause of hemoptysis. This technique buys time for more definitive diagnostic and treatment.

Balloon Tamponade

Balloon catheters can be used for selectively blocking a lobe or segment.[47,50–51] Inserted via the working channel of a flexible bronchoscope or through a rigid scope, the balloon blocks only the bleeding bronchus. This is very helpful in those cases which are not fit for surgery; bilateral extensive disease, poor pulmonary reserve, severe cardiac or systemic diseases. Several types of catheters are available. The disadvantage of using the standard Fogarty catheter is that, it is impossible to remove the flexible bronchoscope when Fogarty catheter is in place. A new bronchus blocking catheter (Rusch, Waiblingen) is available for using in flexible bronchoscope. This catheter has a reattachable valve, a balloon and a second inner channel for drug administration. If necessary, the blocking catheter can be left in place for several days until other measures can be established to control bleeding. Marisco modified a 6-French Foley catheter and 8-French nasogastric tube which can be reliably used to block bleeding bronchus which has the following advantages:

- It is cheap.
- It is durable.
- There is good adaptation to various diameters of tracheobronchial tree.
- It can be easily made in few minutes.

Balloon catheters have certain limitations and inherent problems. They are well suited for use in patients whose rate of bleeding is slow and the location is at segmental level or beyond. The limitations are difficult to control bleeding at lobar bronchus, insertion at upper lobe bronchus is very difficult as the catheter stem straightens out, excessive coughing can dislodge the catheter, blood or mucous in the bronchus can act as a lubricant and help to move the balloon out of the tamponaded site, breakage of balloon can result in foreign body and it prevents suctioning through bronchoscope in cases of continuous hemorrhage.

Isolation of Bronchial Tree

Isolation of the nonbleeding side is important to prevent asphyxiation. The simplest method is selective intubation of the main bronchi (either right or left side) with an ordinary large size endotracheal tube (8 mm). One technique involves the use of flexible bronchoscope to guide the tip of endotracheal tube into bleeding main bronchus and then the scope is withdrawn. A Foley catheter is introduced into the bleeding side and then the tip of the endotracheal tube is slightly withdrawn and placed about 2–3 cm above carina to ventilate the other lung. The most effective method however is the intubation with a double lumen tube. The original Carlens tube has a hook that sits on the carina. Robertshaw tube is a modified form of Carlens tube. Another tube called Inoue endotracheal tube has a blocking catheter separately. The disadvantages of these tubes are that the standard flexible bronchoscope cannot be passed through them; the tube blocks and this sacrifice an entire lung even if the bleeding is segmental or subsegmental.

Fibrin Glue

Attempts have been made with fibrin or fibrin precursors through the bronchoscope to treat hemoptysis[52] but most of the time it remains unsuccessful. Topical thrombin alone 5–10 ml, (1,000 units per ml) or 2% fibrinogen, 5–10 ml followed by thrombin 5–10 ml can be used directly through the working channel of bronchoscope. The bronchoscope is left in place for 5 minutes after which gentle suction is applied to confirm hemostasis. Similarly, cryoprecipitate can be used which reduces the chances of HIV transmission. However, persistent and significant bleeding tends to flush away the fibrin before a stable clot can form.

Laser Coagulation

Small lesions can be coagulated with the laser. Lower energy (about 15 W) is used. However, there are some limitations such as nonvisibilty of bleeding vessel, differentiating tumor and blood clot which may be difficult and attempting to coagulate a heavily bleeding tumor results in boiling of blood without stoppage of bleeding.

Electrocautery

An alternative to laser coagulation is the electrocautery.[53] This is done through rigid bronchoscope as it allows simultaneous suctioning. As soon as the heavy bleeding stops, final coagulation with Nd:YAG laser should be done as this technique has a higher and more reliable depth of penetration. However, the major disadvantage of cauterizing via the bronchoscope is the fact that the coagulation effect stops completely, if the carbonized tissue covers the surface of the electrode. Repetitive cleaning of the electrode is required, making it a time-consuming procedure in a situation where there is no time.

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Other Rare Measures

- *Tampons with vasoconstrictive drugs*: Packing the bronchus with swabs or tampons soaked in vasoconstrictive drugs can be used in emergency when other effective therapy is not available. However, the tampons/swabs can dislodge and can act as foreign bodies.
- *Intrabronchial artery*: Clipping of the bleeding artery in the bronchial lumen have been reported.
- Injection of sclerosing agents to control bleeding from submucosal varices.
- Some authors believe that positive end-expiratory pressure ventilation (PEEP) increases the intrathoracic pressure and serve as tamponade for the bleeding site.
- Collapse therapy with pneumoperitoneum and pneumothorax greatly reduces the blood flow of the collapsed lung. Pneumothorax is contraindicated in cases of pleural adhesion. Pneumoperitoneum is effective only in elastic cavities located in pulmonary bases.
- Radiotherapy was tried in some cases with fungal ball and unresectable cancer with minimum benefit. Radiotherapy causes swelling, necrosis and thrombosis of blood vessels. Eventually perivascular and medial fibrosis occludes the vessels.
- There are relatively few indications for urgent percutaneous tube drainage of a cavitary pulmonary lesion in a patient with massive hemoptysis. The radiologic criteria proposed by Thoms et al are emptying and refilling of abscess cavity where refilling indicates massive hemorrhage in the cavity, change of air filled cavity to an uniform radiodense round opacity/movable mass and persistent radiodensity pattern. All these signs were recognized as possible predictors of ongoing hemorrhage in the abscess cavity.

BRONCHIAL ARTERY EMBOLIZATION

Immediate localization of the bleeding site followed by early thoracotomy and resection of the bleeding source constitutes ideal management.[54,55] Unfortunately, in many instances, poor pulmonary reserve and other medical comorbidities decrease the patient's ability to tolerate surgical intervention. Bronchial artery embolization has gained popularity as a means of controlling massive hemoptysis in recent years, especially for patients with significant operative risk. It was first successfully performed in 1973, since then there have been many refinements to the technique both in catheters and in the embolic agents and contrast media. Embolization is best performed using digital subtraction, nonionic contrast media and relatively small catheters (5-French) with no side holes. Catheter position must be secure and it is preferable to occlude the vessels from as distal a position as possible. This often necessitates the use of slippery guidewires and coaxial systems. Liquid embolic agents, such as absolute alcohol, are potentially hazardous and particulate agents should always be used. Polyvinyl alcohol (PVA) is probably the best and safest occluding agent currently available. They are biocompatible, nonbiodegradable and are considered to be a permanent embolic agent. During its injection, it is essential to screen continuously, in order to recognize alternative arterial pathways which open up, as occlusion of the main feeding vessels takes place. Using this technique, it should be possible to avoid occlusion of the spinal artery.

Angiographic signs in hemoptysis include hyperplasia of the bronchial arterial trunk and branches, bronchopulmonary anastomoses and bronchial arterial aneurysms.[56] Although, extravasation of contrast medium is a frequent and specific angiographic sign in extrapulmonary bleeding, such extravasation is rarely seen in patients with hemoptysis. Nonbronchial systemic collateral vessels from intercostal, axillary, subclavian, internal mammary and phrenic arteries can also contribute to hemoptysis, when they supply areas of parenchymal lung disease. Embolization of these additional vessels may be required to control bleeding in selected patients. The other materials used for bronchial artery embolization are Tris-acryl gelatine microspheres, Gelfoam, Gianturco coils, Ivanlon. Interlocking detachable coil (IDC) has been recently introduced for bronchial artery embolization. It is a mechanically detachable coil, and its ideal shape can be chosen until its final release.[57]

Despite its immediate effectiveness in achieving hemostasis, bronchial artery embolization may not be a permanent solution for some patients with massive hemoptysis. Bleeding recurs in as many as 30% of these patients as a result of incomplete embolization, revascularization, recanalization of embolized vessels, the bleeding may be from pulmonary circulation (<10% of cases with massive hemoptysis) or inadequate treatment of underlying disease. Also, the success of this procedure is dependent on the expertise and skill of the radiologist. Though this procedure is efficient, it is not available in most of the centers. Minor reactions that may occur with embolotherapy include chest pain, fever and dysphagia, which usually resolve within a few days. The most serious complication of the procedure is potential injury to the spinal cord.[58,59] Spinal arteries arise from bronchial arteries, particularly the right bronchocostal trunk, in about 5% of patients. Injection of contrast agents (particularly those with high neurotoxicity) or therapeutic embolization in these patients can result in serious neurologic complications. The arteriogram, therefore, should include the thoracic spinal region, so that spinal arteries originating from the bronchial artery may be detected. Visualization of spinal arteries arising from the bronchial artery is a relative contraindication to repeated contrast injections as well as to therapeutic embolization.[59] In order to prevent spinal injury, super selective bronchial artery embolization (ssBAE) can be done, in which the bronchial artery forming the common trunk with spinal artery is selectively embolized by using metallic coils.[60] In addition, ischemic bronchial or pulmonary injury associated with the embolization is possible. However, the ability of the bronchopulmonary circulation to withstand bronchial artery occlusion is illustrated by transplantation of the lung, which can be performed without reconstituting the bronchial arteries.[61] It is only when very small microspheres virtually fill the terminal bronchial branches that bronchial injury can occur.

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