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GOLDMAN'S
CECIL
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西氏内科学

第24版

呼吸系统疾病与危重症分册

LEE GOLDMAN
ANDREW I. SCHAFER

北京大学医学出版社

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24TH EDITION

LEE GOLDMAN, MD
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北京大学医学出版社

Peking University Medical Press

图书在版编目（CIP）数据

西氏内科学：第24版. 呼吸系统疾病与危重症分册：英文/（美）戈德曼（Goldman，L.），（美）谢弗（Schafer，A. I.）主编. —影印本. —北京：北京大学医学出版社，2012.1

ISBN 978-7-5659-0323-6

Ⅰ.①西… Ⅱ.①戈…②谢… Ⅲ.①内科学-英文 ②呼吸系统疾病-诊疗-英文 ③内科-险症-诊疗-英文 Ⅳ.①R5

中国版本图书馆CIP数据核字（2011）第254615号

This edition of pages 511 through 706 of Goldman's Cecil Medicine, 24th Edition by Lee Goldman, Andrew I. Schafer is published by arrangement with Elsevier Inc.

ISBN-13：978-1-4377-1604-7

ISBN-10：1-4377-1604-0

Elsevier (Singapore) Pte Ltd.

3 Killiney Road #08-01 Winsland House I,

Singapore 239519

Tel：(65) 6349-0200

Fax：(65) 6733-1817

First Published 2012

2012年初版

北京市版权局著作权合同登记号：图字：01-2011-6967

西氏内科学（第24版）——呼吸系统疾病与危重症分册

主　　编：Lee Goldman，Andrew I. Schafer
出版发行：北京大学医学出版社（电话：010-82802230）
地　　址：（100191）北京市海淀区学院路38号　北京大学医学部院内
网　　址：http://www.pumpress.com.cn
E-mail：booksale@bjmu.edu.cn
印　　刷：北京画中画印刷有限公司
经　　销：新华书店
责任编辑：冯智勇　　**责任印制**：张京生
开　　本：889mm×1194mm　1/16　　**印张**：12.75　　**字数**：655千字
版　　次：2012年1月第1版　2012年1月第1次印刷
书　　号：ISBN 978-7-5659-0323-6
定　　价：66.00元

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PREFACE

The 24TH Edition of *Goldman's Cecil Medicine* symbolizes a time of extraordinary advances in medicine and in technological innovations for the dissemination of information. This textbook and its associated electronic products incorporate the latest medical knowledge in formats that are designed to appeal to learners who prefer to access information in a variety of ways.

The contents of *Cecil* have remained true to the tradition of a comprehensive textbook of medicine that carefully explains the *why* (the underlying normal physiology and pathophysiology of disease, now at the cellular and molecular as well as the organ level) and the *how* (now frequently based on Grade A evidence from randomized controlled trials). Descriptions of physiology and pathophysiology include the latest genetic advances in a practical format that strives to be useful to the nonexpert. Medicine has entered an era when the acuity of illness and the limited time available to evaluate a patient have diminished the ability of physicians to satisfy their intellectual curiosity. As a result, the acquisition of information, quite easily achieved in this era, is often confused with knowledge. We have attempted to counteract this tendency with a textbook that not only informs but also stimulates new questions and gives a glimpse of the future path to new knowledge. Grade A evidence is specifically highlighted in the text and referenced at the end of each chapter. In addition to the information provided in the textbook, the Cecil website supplies expanded content and functionality. In many cases, the full articles referenced in each chapter can be accessed from the Cecil website. The website is also continuously updated to incorporate subsequent Grade A information, other evidence, and new discoveries.

The sections for each organ system begin with a chapter that summarizes an approach to patients with key symptoms, signs, or laboratory abnormalities associated with dysfunction of that organ system. As summarized in Table 1-1, the text specifically provides clear, concise information regarding how a physician should approach more than 100 common symptoms, signs, and laboratory abnormalities, usually with a flow diagram, a table, or both for easy reference. In this way, *Cecil* remains a comprehensive text to guide diagnosis and therapy, not only for patients with suspected or known diseases but also for patients who may have undiagnosed abnormalities that require an initial evaluation.

Just as each edition brings new authors, it also reminds us of our gratitude to past editors and authors. Previous editors of *Cecil Medicine* include a short but remarkably distinguished group of leaders of American medicine: Russell Cecil, Paul Beeson, Walsh McDermott, James Wyngaarden, Lloyd H. Smith, Jr., Fred Plum, J. Claude Bennett, and Dennis Ausiello. As we welcome new associate editors—Wendy Levinson, Donald W. Landry, Anil Rustgi, and W. Michael Scheld—we also express our appreciation to Nicholas LaRusso and other associate editors from the previous editions on whose foundation we have built. Our returning associate editors—William P. Arend, James O. Armitage, David Clemmons, Jeffrey M. Drazen, and Robert C. Griggs—continue to make critical contributions to the selection of authors and the review and approval of all manuscripts. The editors, however, are fully responsible for the book as well as the integration among chapters.

The tradition of *Cecil Medicine* is that all chapters are written by distinguished experts in each field. We are also most grateful for the editorial assistance in New York of Theresa Considine and Silva Sergenian. These individuals and others in our offices have shown extraordinary dedication and equanimity in working with authors and editors to manage the unending flow of manuscripts, figures, and permissions. We also thank Faten Aberra, Reza Akari, Robert C. Brunham, Ivan Ciric, Seema Daulat, Gregory F. Erikson, Kevin Ghassemi, Jason H. Huang, Caron Jacobson, Lisa Kachnic, Bryan T. Kelly, Karen Krok, Heather Lehman, Keiron Leslie, Luis Marcos, Michael Overman, Eric Padron, Bianca Maria Piraccini, Don W. Powell, Katy Ralston, James M. Swain, Tania Thomas, Kirsten Tillisch, Ali Turabi, Mark Whiteford, and Y. Joseph Woo, who contributed to various chapters. At Elsevier, we are most indebted to Dolores Meloni and Linda McKinley, and also thank Cathy Carroll, Taylor Ball, Virginia Wilson, Linda Van Pelt, Suzanne Fannin, and Steve Stave, who have been critical to the planning and production process under the direction of Mary Gatsch. Many of the clinical photographs were supplied by Charles D. Forbes and William F. Jackson, authors of *Color Atlas and Text of Clinical Medicine*, Third Edition, published in 2003 by Elsevier Science Ltd. We thank them for graciously permitting us to include their pictures in our book. We have been exposed to remarkable physicians in our lifetimes and would like to acknowledge the mentorship and support of several of those who exemplify this paradigm—Robert H. Gifford, Lloyd H. Smith, Jr., Frank Gardner, and William Castle. Finally, we would like to thank the Goldman family—Jill, Jeff, Abigail, Mira, Daniel, and Robyn Goldman—and the Schafer family—Pauline, Eric, Pam, John, Evan, and Kate—for their understanding of the time and focus required to edit a book that attempts to sustain the tradition of our predecessors and to meet the needs of today's physician.

LEE GOLDMAN, MD
ANDREW I. SCHAFER, MD

CONTENTS

IX

RESPIRATORY DISEASES

83 APPROACH TO THE PATIENT WITH RESPIRATORY DISEASE

MONICA KRAFT

Respiratory symptoms, which are among the most common reasons why patients seek medical care, are responsible for about 20% of office visits to a primary care physician. Key common respiratory complaints include cough, wheezing, dyspnea, and hemoptysis.

APPROACH TO THE PATIENT WITH COUGH

Cough is the single most common respiratory complaint for which patients seek care. Referrals of patients with persistently troublesome chronic cough of unknown etiology account for 10 to 38% of outpatient visits to respiratory specialists.

For acute cough, defined as coughing that has been present for less than 8 weeks, a careful medical history and physical examination will usually reveal the diagnosis (Table 83-1). Although most acute coughs are of minor consequence, cough can occasionally be a sign of a potentially life-threatening illness, such as pulmonary embolism (Chapter 98), pneumonia (Chapter 97), or heart failure (Chapter 58).

Up to 98% of all cases of chronic cough, defined as a cough that persists for more than 8 weeks, in immunocompetent adults are caused by eight common conditions: postnasal drip syndrome from a variety of rhinosinus conditions (Chapter 259), asthma (Chapter 87), gastroesophageal reflux disease (GERD) (Chapter 140), chronic bronchitis (Chapter 88), eosinophilic bronchitis, bronchiectasis (Chapter 90), use of angiotensin-converting enzyme (ACE) inhibitors, and postinfectious cough. Postinfectious cough is usually nonproductive and lasts for 3 to 8 weeks following an upper respiratory infection; patients have a normal chest radiograph. Uncommon causes of chronic cough include bronchogenic carcinoma (Chapter 197), chronic interstitial pneumonia (Chapter 92), sarcoidosis (Chapter 95), left ventricular failure (Chapter 58), and aspiration (Chapter 94).

DIAGNOSIS

In chronic cough (Fig. 83-1), the character and timing are not of diagnostic help. A chest radiograph should be obtained in all patients, but other tests should not be ordered in current smokers or patients taking ACE inhibitors until the response to smoking cessation or discontinuation of the drug for at least 4 weeks can be assessed. Sinus radiographs, barium esophagography, methacholine challenge, esophageal pH, and bronchoscopy can be ordered as part of the initial evaluation, depending on the history and physical examination (Table 83-2; see Fig. 83-1). If a test points toward a possible diagnosis, a trial of treatment for that condition is needed to confirm the diagnosis.

TREATMENT

Rx

The specific cause of cough can be diagnosed and treated successfully 84 to 98% of the time, so nonspecific therapy aimed to suppress the cough per se is rarely indicated. There is no strong evidence that nonspecific therapies such as antitussives, mucolytics, decongestants, or antihistamine-decongestant combinations are efficacious for acute cough in the setting of an upper respiratory tract infection.[1] For nonspecific persistent cough, effective treatment of chronic gastroesophageal reflux disease with a proton pump inhibitor (Chapter 140) provides no more than modest benefit, with about one in five patients improving.[2]

APPROACH TO THE PATIENT WITH WHEEZING

Wheeze is a continuous musical sound that lasts longer than 80 to 100 msec, likely generated by flow though critically narrowed collapsible bronchi. Although expiratory wheezing is a common physical finding in asthma (Chapter 87), the many causes of wheezing (Table 83-3) (e.g., chronic obstructive pulmonary disease [COPD; Chapter 88], pulmonary edema [Chapter 58], bronchiolitis [Chapter 92], bronchiectasis [Chapter 90], and less common entities such as carcinoid [Chapter 240] and parasitic infections) often can be distinguished based on the history, physical examination, and pulmonary function testing (Chapter 85).

DIAGNOSIS

On pulmonary function testing, the shape of inspiratory and expiratory flow-volume loops provides key information about the presence of airway obstruction and whether the obstruction is extrathoracic or intrathoracic (Fig. 83-2). An important cause of extrathoracic obstruction is vocal cord lesions (Chapter 196). Variable intrathoracic obstruction can be caused by tracheomalacia, whereas fixed upper airway obstruction can be caused by a proximal tracheal tumor.

TREATMENT

Rx

Treatment of the specific cause will usually lead to complete or at least partial resolution of wheezing. However, treatment of associated asymptomatic or minimally symptomatic gastroesophageal reflux disease is not beneficial.[3]

APPROACH TO THE PATIENT WITH DYSPNEA

Dyspnea is the sensation of difficult, labored, or unpleasant breathing. The word *unpleasant* is very important to this definition because the labored or difficult breathing encountered by healthy individuals while exercising does not qualify as dyspnea because it is at the level expected for the degree of exertion. The sensation of dyspnea is often poorly or vaguely described by the patient. The physiology of dyspnea remains unclear, but multiple neural pathways can be involved in processes that lead to dyspnea.

In acute dyspnea, or shortness of breath of sudden onset, the history, physical examination, and laboratory testing must first focus on potential life-threatening conditions, including pulmonary embolism (Chapter 98), pulmonary edema (Chapters 58 and 59), acute airway obstruction from anaphylaxis or foreign bodies, pneumothorax (Chapter 99), or pneumonia (Chapter 97). For chronic dyspnea, specific conditions to consider include COPD (Chapter 88), asthma (Chapter 87), interstitial lung disease (Chapter 92), heart failure (Chapter 58), cardiomyopathy (Chapter 60), GERD (Chapter 140), other respiratory diseases, or hyperventilation syndrome.

DIAGNOSIS

A chest radiograph, electrocardiogram, pulmonary function testing, and an exercise test with electrocardiographic (ECG) monitoring and pulse oximetry at rest and during exercise are key tests to assess patients with unexplained dyspnea (Fig. 83-3). For acute dyspnea, B-type natriuretic peptide testing can be extremely helpful in distinguishing heart failure from other causes.[4] The utility of more detailed pulmonary testing with maximal inspiratory and expiratory pressures, flow-volume loops, with or without methacholine challenge, computed tomographic screening of the chest, and echocardiography depends on history and physical examination and the results of these tests. When GERD is a suspected cause of dyspnea, a modified barium esophagogram or 24-hour esophageal pH monitoring, or both, should be considered (Chapter 140). Other more invasive tests such as cardiac catheterization or lung biopsy may be indicated when the results of less invasive tests have not been conclusive.

TREATMENT

Rx

Whenever possible, the final determination of the cause of dyspnea is made by observing which specific therapy eliminates it. Because dyspnea may be simultaneously due to more than one condition, it may be necessary to treat more than one condition.

APPROACH TO THE PATIENT WITH HEMOPTYSIS

Hemoptysis is the expectoration of blood from the lung parenchyma or airways. Hemoptysis may be scant, with just the appearance of streaks of bright red blood in the sputum, or massive, with the expectoration of a large volume of blood. Massive hemoptysis, which is defined as the expectoration of at least 600 mL of blood in 24 to 48 hours, may occur in 3 to 10% of

patients with hemoptysis. Dark red clots may also be expectorated when the blood has been present in the lungs for days.

Pseudohemoptysis, which is the expectoration of blood from a source other than the lower respiratory tract, may cause diagnostic confusion when patients cannot clearly describe the source of their bleeding. Pseudohemoptysis can occur when blood from the oral cavity, nares, pharynx, or tongue clings to the back of the throat and initiates the cough reflex, or when patients who have hematemesis aspirate into the lower respiratory tract. When the oropharynx is colonized with *Serratia marcescens*, a red-pigment-producing aerobic gram-negative rod, the sputum can also be red and be confused with hemoptysis.

Hemoptysis can be caused by a wide variety of disorders. Virtually all causes of hemoptysis (Table 83-4) may result in massive hemoptysis, but massive hemoptysis is most frequently caused by infection (e.g., tuberculosis [Chapter 332], bronchiectasis and lung abscess [Chapter 90], and cancer [Chapter 197]). Infections with aspergilloma (Chapter 347) and in patients with cystic fibrosis (Chapter 89) also are associated with massive hemoptysis. Iatrogenic causes of massive hemoptysis include rupture of a pulmonary

TABLE 83-1

COMMON	LESS COMMON
ACUTE COUGH	
Common cold	Asthma
Acute bacterial sinusitis	Pneumonia
Pertussis	Heart failure
Exacerbations of COPD	Aspiration syndromes
Allergic rhinitis	Pulmonary embolism
Environmental irritant rhinitis	Exacerbation of bronchiectasis
CHRONIC COUGH	
Rhinosinus conditions	Bronchogenic carcinoma
Asthma	Chronic interstitial pneumonia
Gastroesophageal reflux	Sarcoidosis
Chronic bronchitis	Left heart failure
Eosinophilic bronchitis	
Bronchiectasis	
ACE inhibitors	
Postinfection	

ACE = angiotensin converting enzyme; COPD = chronic obstructive pulmonary disease.

TABLE 83-2

TESTS	DIAGNOSIS	POSITIVE PREDICTIVE VALUE, %	NEGATIVE PREDICTIVE VALUE, %
Sinus radiograph	Sinusitis	57-81	95-100
Methacholine inhalation challenge	Asthma	60-82	100
Modified barium esophagography	GERD, esophageal stricture	38-63	63-93
Esophageal pH*	GERD	89-100	<100
Bronchoscopy	Endobronchial mass/ lesion	50-89	100

*24-Hour esophageal pH monitoring.
GERD = gastroesophageal reflux disease.

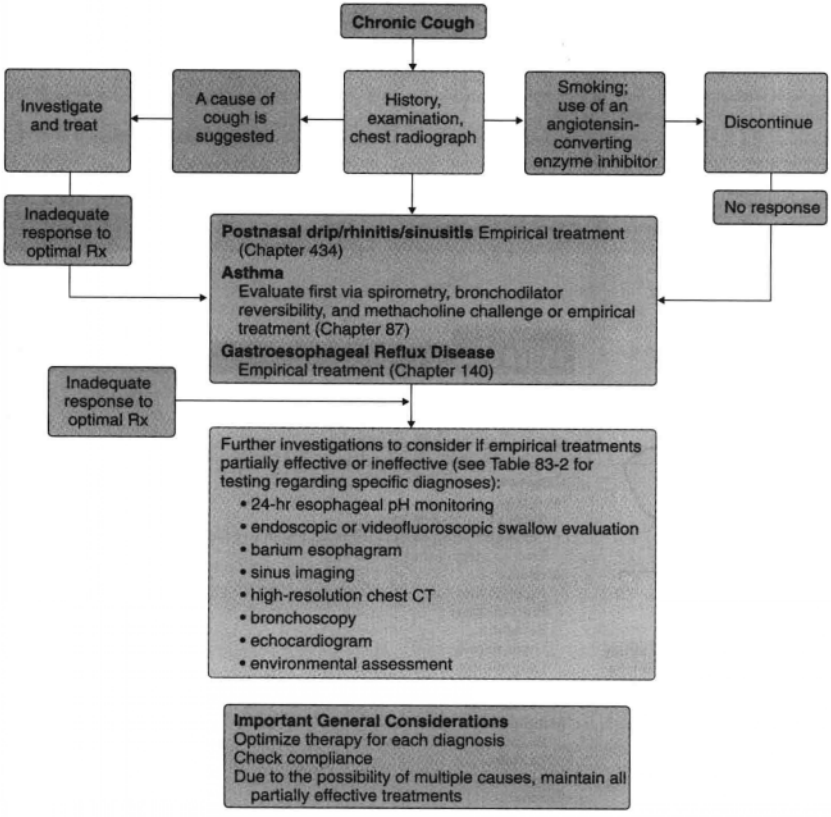

FIGURE 83-1. Algorithm for the management of chronic cough lasting >8 weeks. CT = computed tomography; Rx = prescription.

TABLE 83-3 DIAGNOSIS OF SELECTED WHEEZING ILLNESSES OTHER THAN ASTHMA

	DISTINGUISHING FEATURES
UPPER AIRWAY DISEASES	
Postnasal drip syndrome	History of postnasal drip, throat clearing, nasal discharge; physical exam shows oropharyngeal secretions or cobblestone appearance to mucosa.
Epiglottis	History of sore throat out of proportion to pharyngitis. Evidence of supraglottitis on endoscopy or lateral neck radiographs.
Vocal cord dysfunction syndrome	Lack of symptomatic response to bronchodilators, presence of stridor plus wheeze in absence of increased $P(A\text{-}a)o_2$; extrathoracic variable obstruction on flow-volume loops; paradoxical inspiratory and/or early expiratory adduction of vocal cords on laryngoscopy during wheezing. This syndrome can masquerade as asthma, be provoked by exercise, and often coexists with asthma.
Retropharyngeal abscess	History of stiff neck, sore throat, fever, trauma to posterior pharynx; swelling noted by lateral neck or CT radiographs.
Laryngotracheal injury due to tracheal cannulation	History of cannulation of trachea by endotracheal or tracheostomy tube; evidence of intrathoracic or extrathoracic variable obstruction on flow-volume loops, neck and chest radiographs, laryngoscopy, or bronchoscopy.
Neoplasms	Bronchogenic carcinoma, adenoma, or carcinoid tumor is suspected when there is hemoptysis, unilateral wheeze, or evidence of lobar collapse on chest radiograph or combinations of these; diagnosis is confirmed by bronchoscopy.
Anaphylaxis	Abrupt onset of wheezing with urticaria, angioedema, nausea, diarrhea, and hypotension, especially following insect bite, in association with other signs of anaphylaxis such as hypotension or hives, or administration of drug or IV contrast, or family history.
LOWER AIRWAY DISEASES	
COPD	History of dyspnea on exertion and productive cough in cigarette smoker. Because productive cough is nonspecific, it should only be ascribed to COPD when other cough-phlegm syndromes have been excluded, forced expiratory time to empty more than 80% of vital capacity >4 sec, and there is decreased breath sound intensity, unforced wheezing during auscultation, and irreversible, expiratory airflow obstruction on spirometry.
Pulmonary edema	History and physical exam consistent with passive congestion of the lungs, ARDS, impaired lung lymphatics; abnormal chest radiograph, echocardiogram, radionuclide ventriculography, cardiac catheterization, or combinations of these.
Aspiration	History of risk for pharyngeal dysfunction or gastroesophageal reflux disease; abnormal modified barium swallow and/or 24-hr esophageal pH monitoring.
Pulmonary embolism	History of risk for thromboembolic disease, positive confirmatory tests.
Bronchiolitis	History of respiratory infection, connective tissue disease, transplantation, ulcerative colitis, development of chronic airway obstruction over months to a few years rather than over many years in a nonsmoker; mixed obstructive and restrictive pattern on PFTs and hyperinflation; may be accompanied by fine nodular infiltrates on chest radiograph.
Cystic fibrosis	Combination of productive cough, digital clubbing, bronchiectasis, progressive COPD with *Pseudomonas* species colonization and infection, obstructive azoospermia, family history, pancreatic insufficiency, and two sweat chloride determinations of >60 mEq/L; some patients are not diagnosed until adulthood, in one instance as late as age 69 yr; when sweat test is occasionally normal, definitive diagnosis may require nasal transepithelial voltage measurements and genotyping.
Carcinoid syndrome	History of episodes of flushing and watery diarrhea; elevated 5-hydroxyindoleactic acid level in 24-hr urine specimen.
Bronchiectasis	History of episodes of productive cough, fever, or recurrent pneumonias; suggestive chest radiographs or typical chest CT findings; ABPA should be considered when bronchiectasis is central.
Lymphangitic carcinomatosis	History of dyspnea or prior malignancy; reticulonodular infiltrates with or without pleural effusions; suggestive high-resolution chest CT scan; confirmed by bronchoscopy with biopsies.
Parasitic infections	Consider in a nonasthmatic patient who has traveled to an endemic area and complains of fatigue, weight loss, fever; peripheral blood eosinophilia; infiltrates on chest radiograph; stools for ova and parasites for nonfilarial causes; blood serologic studies for filarial causes.

ABPA = allergic bronchopulmonary aspergillosis; ARDS = acute respiratory distress syndrome; COPD = chronic obstructive pulmonary disease; CT = computed tomography; IV = intravenous; $P(A\text{-}a)o_2$ = alveolar-arterial oxygen tension gradient; PFTs = pulmonary function tests.

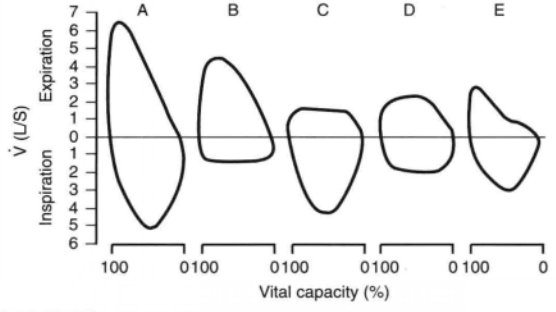

FIGURE 83-2. Schematic flow-volume loop configurations in a spectrum of airway lesions. *A* is normal; *B* is variable extrathoracic upper airway obstruction; *C* is variable intrathoracic upper airway lesion; *D* is fixed upper airway obstruction; and *E* is small airway obstruction. L/S = liters per second; V̇ = ventilation.

TABLE 83-4 COMMON CAUSES OF MASSIVE HEMOPTYSIS

- Cardiovascular
  - Arterial bronchial fistula
  - Heart failure, especially from mitral stenosis
  - Pulmonary arteriovenous fistula
- Diffuse intrapulmonary hemorrhage
- Diffuse parenchymal disease
- Iatrogenic
  - Malposition of chest tube
  - Pulmonary artery rupture following pulmonary arterial catheterization
  - Tracheoarterial fistula
- Infections
  - Aspergilloma
  - Bronchiectasis
  - Bronchitis
  - Cystic fibrosis
  - Lung abscess
  - Sporotrichosis
  - Tuberculosis
- Malignancies
  - Bronchogenic carcinoma
  - Leukemia
  - Metastatic cancer
- Trauma

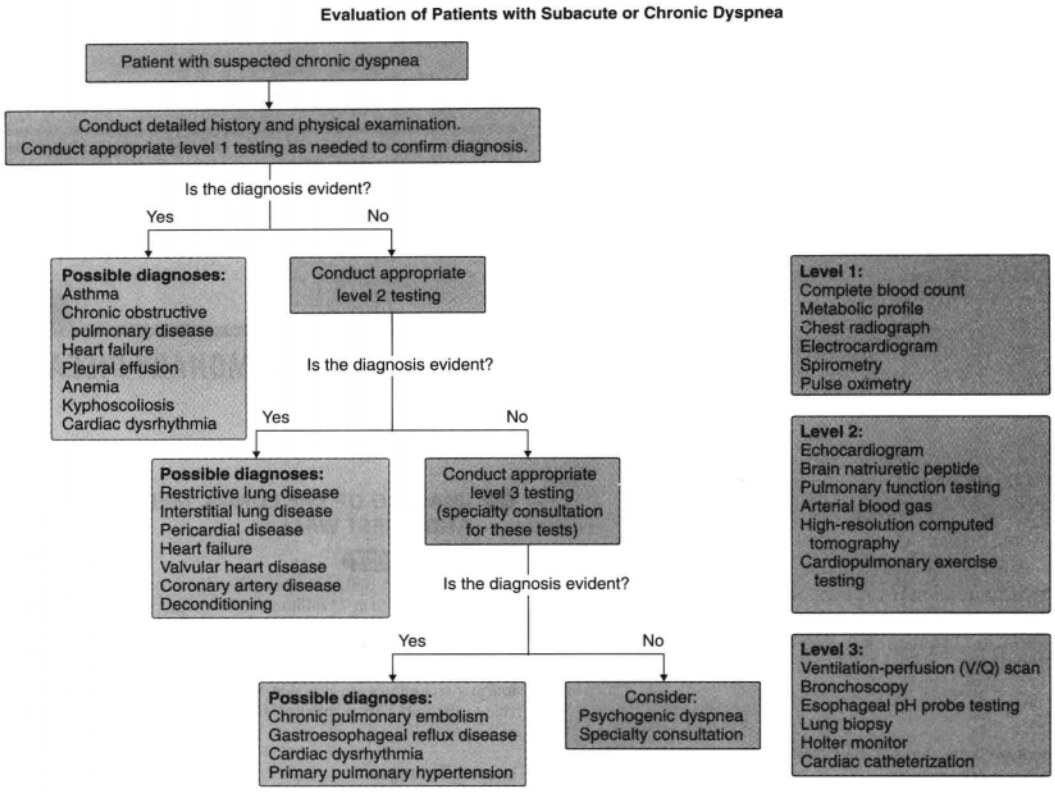

FIGURE 83-3. Algorithm outlining the approach to chronic dyspnea. (Modified from Karnani NG, Reisfield GM, Wilson GR. Evaluation of chronic dyspnea. *Am Fam Phys.* 2005;71:1529-1537.)

artery after less than 0.2% of cases of balloon-guided flotation catheterization and tracheal artery fistula as a complication of tracheostomy.

In nonmassive hemoptysis, the etiology is bronchitis in more than one third of cases (Chapter 88), bronchogenic carcinoma (Chapter 197) in one fifth of cases, tuberculosis (Chapter 332) in 7%, pneumonia (Chapter 97) in 5%, and bronchiectasis in 1% (Chapter 90). Using a systematic diagnostic approach (see later), the cause of hemoptysis can be found in 68 to 98% of cases. The remaining 2 to 32% have idiopathic or central hemoptysis, which occurs most commonly in men between the ages of 30 and 50 years. Prolonged follow-up of idiopathic hemoptysis almost always fails to reveal the source of bleeding, even though 10% continue to have occasional episodes of hemoptysis.

DIAGNOSIS

The diagnostic evaluation for hemoptysis begins with a detailed medical history and a complete physical examination. Information on the amount of bleeding should be obtained, as well as details about the frequency, timing, and duration of hemoptysis. For example, repeated episodes of hemoptysis occurring over a period of months to years suggest a bronchial adenoma or bronchiectasis as the cause, whereas small amounts of hemoptysis occurring every day for weeks are more likely to be caused by bronchogenic carcinoma. A travel history can suggest coccidioidomycosis (Chapter 341) and histoplasmosis (Chapter 340) in the United States, paragonimiasis and ascariasis (Chapter 366) in the Far East, and schistosomiasis (Chapter 363) in South America. Orthopnea and paroxysmal nocturnal dyspnea suggest heart failure (Chapter 58), especially from mitral stenosis (Chapter 75). In patients who have occupational exposure to trimellitic anhydride, which occurs when heated metal surfaces are sprayed with a corrosion-resistant epoxy resin, hemoptysis can be part of the postexposure syndrome. In a patient with the triad of upper airway disease, lower airway disease, and renal disease, Wegener's granulomatosis (Chapter 278) should be suspected. Pulmonary hemorrhage may also be a presenting manifestation of systemic lupus erythematosus (Chapter 274). Goodpasture's syndrome, which typically occurs in young men, is also associated with renal disease (Chapter 123). Diffuse alveolar hemorrhage occurs in 20% of cases during autologous bone marrow transplantation (Chapter 181) and should be suspected in patients who have undergone recent bone marrow transplantation (Chapter 181) when they present with cough, dyspnea, hypoxemia, and diffuse pulmonary infiltrates.

On physical examination, inspection of the skin and mucous membranes may show telangiectasias suggesting heredity hemorrhagic telangiectasia (Chapter 176) or ecchymoses and petechiae, suggesting a hematologic abnormality (Chapter 175). Pulsations transmitted to a tracheostomy cannula should heighten suspicion of a tracheal artery fistula. Inspection of the thorax should show evidence of recent or old chest trauma, and unilateral wheeze or rales may herald localized disease such as a bronchial adenoma or carcinoma. Although pulmonary embolism (Chapter 98) cannot be definitively diagnosed on physical examination, tachypnea, phlebitis, and pleural friction rub suggest this disorder. If rales are heard on the chest examination, heart failure as well as other diseases causing diffuse pulmonary hemorrhage (see earlier) or idiopathic pulmonary hemosiderosis (Chapter 92) should be considered. Careful cardiovascular examination may help diagnose mitral stenosis (Chapter 75), pulmonary artery fistulas, or pulmonary hypertension (Chapter 68).

Routine laboratory studies should include a complete blood count, urinalysis, and coagulation studies. The complete blood count may suggest an infection, hematologic disorder, or chronic blood loss. Urinalysis may reveal hematuria and suggest the presence of a systemic disease (e.g., Wegener's granulomatosis, Goodpasture's syndrome, systemic lupus erythematosus) associated with renal disease. Coagulation studies may uncover a hematologic disorder that is primarily responsible for hemoptysis or that contributes to excessive bleeding from another disease. The ECG may help suggest the presence of a cardiovascular disorder. Although as many as 30% of patients

TABLE 83-5 EXAMPLES OF SPECIAL EVALUATIONS FOR HEMOPTYSIS ACCORDING TO CATEGORY OF DISEASE*

TRACHEOBRONCHIAL DISORDERS
Expectorated sputum for TB, parasites, fungi, and cytology
Bronchoscopy (if not done)
Bronchography
High-resolution chest CT scan
LOCALIZED PARENCHYMAL DISEASES
Expectorated sputum for TB, parasites, fungi, and cytology
Chest CT scan
Lung biopsy with special stains
DIFFUSE PARENCHYMAL DISEASES
Expectorated sputum for cytology
Blood for BUN, creatinine, ANA, RF, complement, cryoglobulins, ANCA, anti-GBM antibody
Lung or kidney biopsy with special stains
CARDIOVASCULAR DISORDERS
Echocardiogram
Arterial blood gas on 21% and 100% oxygen
Ventilation-perfusion scans
Pulmonary arteriogram
Aortogram, contrast-enhanced CT scan
HEMATOLOGIC DISORDERS
Coagulation studies
Bone marrow

*This table is not meant to be all inclusive.
ANA = antinuclear antibody; ANCA = antineutrophil cytoplasmic antibody; BUN = blood urea nitrogen; CT = computed tomography; GBM = glomerular basement membrane; RF = rheumatoid factor; TB = tuberculosis.

with hemoptysis have a normal chest radiograph, routine chest radiographs may be diagnostically valuable.

Bronchoscopy can localize the bleeding site in up to 93% of patients by fiberoptic bronchoscopy and in up to 86% with rigid bronchoscopy. It may establish sites of bleeding different from those suggested by the chest radiograph. The best results are obtained when bronchoscopy is performed during or within 24 hours of active bleeding, and rates of diagnosis fall to about 50% by 48 hours after bleeding. When there is no active bleeding, bronchoscopy with bronchoalveolar lavage can be helpful in patients thought to have diffuse intrapulmonary hemorrhage. Typical findings include bright red or blood-tinged lavage fluid from multiple lobes in both lungs or a substantial number of hemosiderin-laden macrophages (i.e., at least 20% of the total number of alveolar macrophages).

Depending on the results of the initial evaluation and the likely categories of hemoptysis, additional diagnostic tests can be helpful (Table 83-5). Bronchoscopy may not be needed in patients who have stable chronic bronchitis (Chapter 88) with one episode of blood streaking or who have acute tracheobronchitis (Chapter 88). Bronchoscopy may also not be needed with obvious cardiovascular causes of hemoptysis, such as heart failure and pulmonary embolism.

TREATMENT

Rx

Treatment is targeted toward the cause of hemoptysis. Bronchoscopic approaches (Chapter 101) are increasingly used for endobronchial lesions.

Grade A

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SUGGESTED READINGS

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84 IMAGING IN PULMONARY DISEASE

PAUL STARK

IMAGING OF THE LUNGS, MEDIASTINUM, AND CHEST WALL

EPIDEMIOLOGY

Worldwide, chest radiography is the most commonly performed imaging procedure; more than 75 million chest radiographs are performed every year in the United States alone. Chest radiographs provide useful information about the patient's anatomy and disease at a minimal monetary cost and with radiation exposure that most experts agree is negligible. Although many novel imaging techniques are available, the plain chest radiograph remains invaluable in the initial assessment of disorders of the lung, pleura, mediastinum, and chest wall.

Imaging Techniques

Chest radiographs, although classically obtained with cassettes and x-ray film, are now commonly acquired by digital imaging with electronic display at workstations and distribution of data through networks. Regardless of the image processing approach used, the standard chest radiograph is performed at 2 m from the x-ray tube focal spot to the image detector, in frontal and lateral projections. If possible, the radiographs should be obtained with the patient inhaling to total lung capacity. These images provide views of the lungs, mediastinum, and chest wall simultaneously.

Portable Radiography

Although bedside or portable radiography accounts for a large number of chest radiographs, the images obtained are generally of lower technical quality, cost more, and are more difficult to interpret. Lung volumes are low, thereby leading to crowding of vascular structures, and the low kilovoltage technique required for the mobile equipment yields radiographs with overexposed lungs and an underpenetrated mediastinum. The anteroposterior projection and the slightly lordotic angulation of the x-ray beam combine to distort the basal lung structures and magnify the cardiac silhouette. Recumbent studies also make recognition of pleural effusions or pneumothoraces more difficult.

Computed Tomography

Computed tomography (CT) has multiple advantages over conventional radiography. It displays cross-sectional anatomy free of superimposition, with a ten-fold higher contrast resolution. Multislice CT scanners acquire a continuous, volumetric, isotropic data set with possibilities for high-quality two-dimensional or three-dimensional reformatting (volume rendering) in any plane. High-resolution CT of the lung parenchyma is an important application; narrow collimation of the beam combined with an edge-enhancing high spatial frequency algorithm results in exquisite detail of normal and abnormal lungs, and correlation with pathologic anatomy is high.

Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) depends on the magnetic properties of hydrogen atoms. Magnetic coils and radio frequency coils lead to induction,

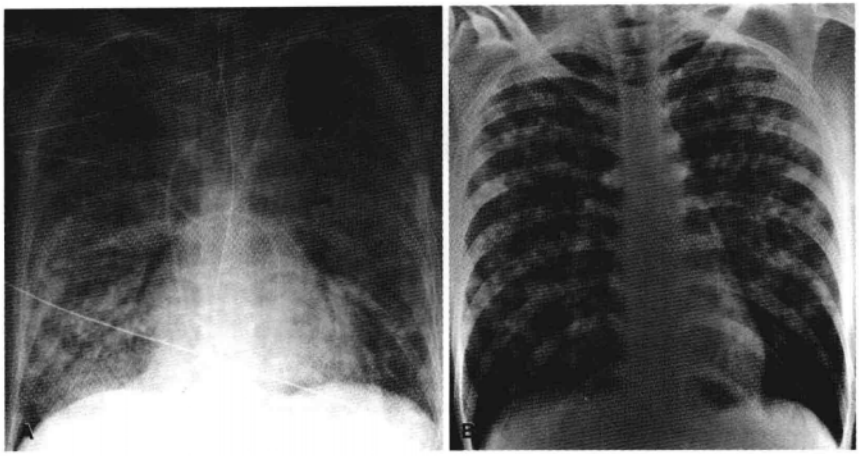

FIGURE 84-1. A, Patient with diffuse alveolar damage. Chest radiograph shows diffuse homogeneous opacification of both lungs with clearly visible air bronchograms. **B,** Patient with acute varicella pneumonia. Chest radiograph demonstrates multiple "acinar" nodules with tendency for confluence, yielding multifocal patchy parenchymal opacification.

excitation, and eventual readout of magnetized protons. The molecular environment of hydrogen atoms will affect the rate at which they release energy; this energy yields a spatial distribution of signals that is converted into an image by computer algorithms, similar to CT. Because of its soft tissue specificity, MRI has applications in the assessment of chest wall invasion, mediastinal infiltration, and diaphragmatic involvement by lung cancer or malignant mesothelioma.

Positron Emission Tomography

Fluorodeoxyglucose positron emission tomography (FDG-PET) uses labeled fluorodeoxyglucose to image the glycolytic pathway of tumor cells or other metabolically active tissues with affinity for glucose. This technique has proved helpful in studying intrathoracic tumors and has facilitated the work-up of solitary pulmonary nodules. Integrated PET-CT scans have improved the diagnosis and staging of intrathoracic tumors.[1]

Ultrasonography

Outside the heart, ultrasonography plays only a limited role in thoracic imaging. Its primary use is to localize pleural effusions and to guide their drainage.

Evaluation of Chest Images

Images of the chest are best evaluated by examining regions of the lung for specific findings and relating these findings to known diagnostic groups. A number of critical radiographic features should be considered, with an appreciation for the known causes of these changes.

Diffuse Lung Disease

Diffuse lung disease is an overall term for a number of related abnormal parenchymal radiographic patterns. Although radiologists have attempted to separate alveolar from interstitial lung disease radiographically, this distinction is no longer recommended because the correlation between the radiographic localization to a compartment and the actual histopathologic findings is relatively poor. For example, nodular patterns can be produced by either interstitial or alveolar disease. Conversely, so-called alveolar disease processes can induce an interstitial reaction. Ground-glass opacities can be induced by either alveolar or interstitial disease. Air bronchograms, the presumed paradigm of air space disease, can be identified in a small percentage of patients with predominantly interstitial lung disease, such as sarcoidosis, pulmonary lymphoma, and pulmonary calcinosis.

Because of such limitations, a graphically descriptive approach that combines analysis of predominant opacities, assessment of lung expansion, and distribution and profusion of disease yields a differential diagnosis. The term *infiltrate* should be avoided; instead, pulmonary opacities are classified as large (i.e., >1 cm in largest dimension) or small (i.e., <1 cm in diameter).

TABLE 84-1

Diffuse homogeneous
Multifocal patchy
Lobar without atelectasis
Lobar with atelectasis
Perihilar
Peripheral

Large Opacities

Large opacities (Table 84-1) are characterized according to their distribution. Diffuse homogeneous opacities are typical for diffuse alveolar damage (Fig. 84-1A), increased permeability (noncardiogenic) pulmonary edema, diffuse viral pneumonia, or *Pneumocystis jirovecii* pneumonia. Multifocal patchy opacities (see Fig. 84-1B) are found in multifocal bronchopneumonia, recurrent aspiration, or vasculitis. Lobar opacities without atelectasis are typically seen in lobar pneumonia. Lobar opacities with atelectasis often result from obstruction of a lobar bronchus by foreign bodies, tumors, or mucous plugs. Perihilar opacities are seen in hydrostatic pulmonary edema due to left-sided heart failure (Fig. 84-2), renal failure, volume overload, or pulmonary hemorrhage.

Small Opacities

In contrast to the large pulmonary opacities, a number of radiographic patterns characterize small pulmonary opacities in diffuse lung disease. It is helpful to differentiate small nodular, linear, reticular, or combined patterns (Table 84-2). Micronodular opacities, which include nodules 1 mm and smaller in diameter, can result from talc granulomatosis in intravenous drug abusers (Chapter 33), alveolar microlithiasis, rare cases of silicosis, talcosis, coal workers' pneumoconiosis (Chapter 93), and beryllium-induced lung diseases (Chapter 93) as well as from occasional cases of sarcoidosis (Chapter 95) or hemosiderosis. The nodular pattern includes nodules up to 1 cm in diameter. Frequent causes include infections or inflammatory granulomas such as miliary tuberculosis (Chapter 332), sarcoidosis (Chapter 95), fungal diseases, extrinsic allergic alveolitis, and Langerhans cell histiocytosis (Chapter 92).

Linear Patterns

Linear patterns, also called Kerley's lines, are mostly a reflection of thickened interlobular septa. Kerley's A lines, which radiate 2 to 4 cm from the hilum toward the pulmonary periphery and particularly toward the upper lobes (Fig. 84-3), reflect thickening of the axial interstitial compartment and can be a feature of left ventricular failure or allergic reactions. Kerley's B lines,

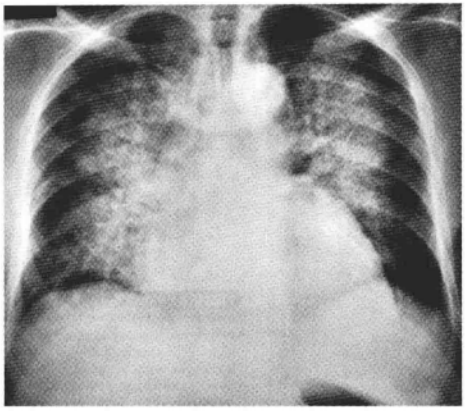

FIGURE 84-2. Patient with hydrostatic pulmonary edema due to left-sided heart failure. Chest frontal radiograph demonstrates classic "batwing" distribution of pulmonary edema.

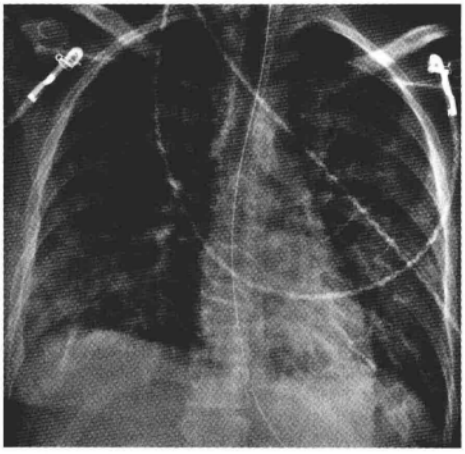

FIGURE 84-3. Patient with known transfusion reaction. Chest radiograph displays ground-glass opacification of both lungs and bilateral Kerley's A lines, presenting as long linear structures extending from the hilar regions into the pulmonary periphery.

TABLE 84-2

Micronodular
Acinar
Linear
Reticular
Bronchial
Arterial
Destructive

which reflect thickening of the subpleural interstitial compartment, typically are about 1 cm in length and 1 mm in thickness and usually found in the periphery of the lower lobes, abutting the pleura. The B lines are characteristic of subacute and chronic left ventricular failure (Chapter 58), mitral valve disease (Chapter 75), lymphangitic carcinomatosis, viral pneumonia, and pulmonary fibrosis (Chapter 92). Kerley's C lines, which are rarely diagnosed by radiologists, result from thickening of the lung parenchymal interstitium and form a reticular pattern on chest radiographs.

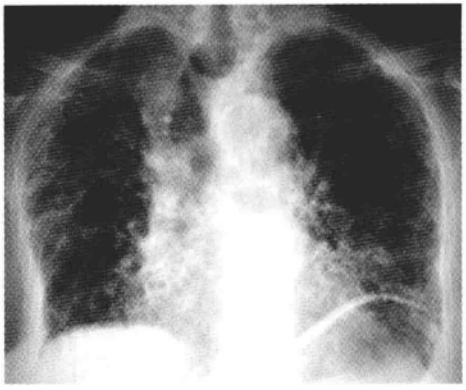

FIGURE 84-4. Diffuse reticular lung disease. Chest radiograph in a 94-year-old patient with diffuse reticular opacities due to idiopathic pulmonary fibrosis with honeycombing and traction bronchiectases. The lung volumes are typically reduced by a decreased pulmonary compliance.

Reticular Patterns

Reticular patterns are small polygonal, irregular, or curvilinear opacities on chest radiographs (Fig. 84-4). The differential diagnosis varies according to the timeline of the pathologic change. Acute onset of a reticular pattern can occur in interstitial edema (e.g., due to left-sided heart failure), atypical pneumonitides (e.g., viral or mycoplasmal pneumonia), early exudative changes in a connective tissue disorder (e.g., systemic lupus erythematosus; Chapter 274), and acute allergic reactions (e.g., transfusion reactions [Chapter 180] or reactions to *Hymenoptera* stings). The common chronic processes resulting in a reticular pattern are idiopathic interstitial pneumonias (Chapter 92), connective tissue diseases (particularly scleroderma and rheumatoid lung), asbestosis (Chapter 93), radiation fibrosis (Chapter 92), end-stage hypersensitivity pneumonia (Chapters 92 and 93), drug reactions, lymphangitic spread of cancer, end-stage granulomatous infection, lymphoma in its bronchovascular form, Kaposi's sarcoma in its bronchovascular manifestation, and sarcoidosis.

Honeycombing

Honeycombing, which is an indication of end-stage interstitial lung disease (Chapter 92), reflects a restructuring of pulmonary anatomy accompanied by bronchiolectasis. Honeycombs form a multilayer of small subpleural spaces between 3 and 10 mm in diameter. They can be distinguished from paraseptal emphysema by their thicker wall and multiple layers.

Alveolar Pattern

An alveolar (Chapter 91) or air space pattern is characterized by acinar nodules, 0.6 to 1 cm in diameter. These nodules encompass more than the acinus, in the strict anatomic sense, with surrounding peribronchiolar lung tissue. Other patterns include ground-glass opacities (a reflection of incomplete alveolar filling), coalescent large opacities, consolidation involving whole lobes or segments, opacification in a bronchocentric distribution, air bronchograms, and air alveolograms. These radiographic features are helpful in placing a disease into a particular radiologic category, but the radiographic pattern called *alveolar* does not simply correspond to exclusive histologic alveolar filling because the interstitial compartment is involved as well in most cases. A more accurate description is parenchymal rather than alveolar opacification or consolidation.

Bronchial Patterns

Bronchial patterns, as best depicted by diffuse bronchiectasis (Chapter 90), are seen on conventional radiographs as linear, tubular, or cystic lucencies and opacities that follow the expected path of bronchi, so-called tramlines because they resemble tram tracks. Mucoid impaction, as seen in patients with asthma, allergic bronchopulmonary aspergillosis, or plastic bronchitis, leads to opacities described as toothpaste, cluster of grapes, or finger-in-glove. The "dirty lung" pattern seen in smokers with chronic bronchitis (Chapter 88) results from bronchial wall thickening, peribronchial fibrosis, respiratory bronchiolitis, and pulmonary arterial hypertension.

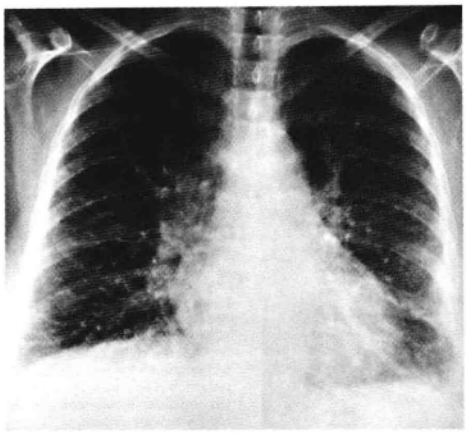

FIGURE 84-5. Patient with left ventricular failure. Chest frontal radiograph shows cephalization of pulmonary blood flow.

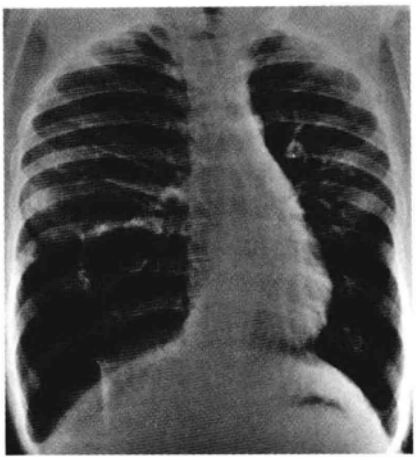

FIGURE 84-7. Patient with severe emphysema. Chest radiograph shows hyperexpansion of both lungs with bullous changes at the right lung base and leftward mediastinal shift.

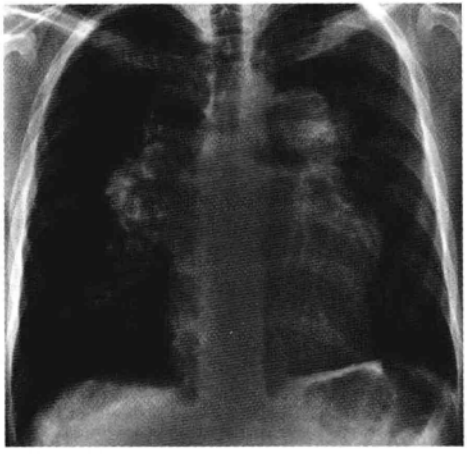

FIGURE 84-6. Patient with primary pulmonary arterial hypertension. Chest frontal radiograph shows centralization of flow with pulmonary artery aneurysms and peripheral pulmonary oligemia.

TABLE 84-3 CONDITIONS ASSOCIATED WITH LUNG VOLUMES IN PATIENTS WITH UNDERLYING DIFFUSE LUNG DISEASE

LARGE LUNG VOLUMES
Emphysema
Chronic asthma
Diffuse bronchiolitis obliterans
Highly trained athletes
Lymphangioleiomyomatosis
SMALL LUNG VOLUMES
End-stage lung fibrosis
Bilateral diaphragmatic paralysis
Massive ascites
NORMAL LUNG VOLUMES
Sarcoidosis
Langerhans cell histiocytosis
Neurofibromatosis
Emphysema with pulmonary fibrosis

Vascular Patterns

Arterial patterns reflect changes in pulmonary perfusion. The term *caudalization* reflects the normal blood flow distribution pattern in an upright person in which the basilar pulmonary vessels are two to three times wider than the upper lobe vasculature. *Cephalization,* in which the ratios of diameters of vessels are reversed, is frequently seen in recumbent persons, in whom it may be considered normal; however, when it is present in individuals imaged in the upright position, it indicates left ventricular failure, mitral valve disease, or basilar emphysema (Fig. 84-5). Equalization, or balanced flow with well-demonstrated vessels to upper and lower lung zones, is found in hyperkinetic circulation due to anemia, obesity, pregnancy, Graves' disease, or left-to-right shunts. Equalization or balanced flow with oligemia can be seen in hypovolemia, diffuse emphysema, or right-to-left shunts. Centralization reflects dilation of central pulmonary vessels, with accompanying normal or diminished peripheral circulation. Typically, it is seen in pulmonary arterial hypertension (Fig. 84-6). Lateralization of flow, favoring one lung over the other, also called *asymmetrical perfusion*, is visible with unilateral emphysema, unilateral bronchiolitis obliterans (Swyer-James-McLeod syndrome), or unilateral obstruction of the pulmonary artery. Locally enlarged vessels occur in patchy emphysema, multiple pulmonary emboli, arteriovenous malformations, and nonuniform bronchiolitis obliterans. This pattern produces a mosaic perfusion on high-resolution CT scanning.

Lung Volume

Conventional radiographs and CT scans are taken during a breath hold at full inspiration. Low lung volumes are inferred by the high position of the diaphragm and the crowding of basal vascular structures (Table 84-3). Lung volumes larger than expected are commonly found in patients with diffuse emphysema (Fig. 84-7) (Chapter 88), chronic asthma (Chapter 87), or diffuse bronchiolitis and in highly trained athletes. With a few rare exceptions, chronic diffuse infiltrative lung diseases (Chapter 92) lead to loss of volume.

Anatomic Distribution

The anatomic distribution of disease can significantly facilitate the approach to diagnosis (Table 84-4 and Fig. 84-8). Upper-zone lung disease predominates in tuberculosis, fungal disease, sarcoidosis, pneumoconiosis (except asbestosis), Langerhans cell histiocytosis, ankylosing spondylitis, cystic fibrosis, cystic *P. jirovecii* pneumonia, radiation pneumonitis, and end-stage hypersensitivity pneumonia. Basal lung disease is preferentially found in bronchiectases, aspiration, desquamative interstitial pneumonia, nonspecific interstitial pneumonia, usual interstitial pneumonia, drug reactions, asbestosis, scleroderma, and rheumatoid arthritis. However, any diffuse lung