86

Selected Disorders of the Respiratory System

George C. Coleman, Richard H. Hoffman, Michael R. Lustig, John G. King, and David W. Marsland

Respiratory Failure

Respiration is a complex physiologic process consisting of the uptake of oxygen and elimination of carbon dioxide, a process involving the movement of gases and the circulation of blood. Respiratory failure is a descriptive term for the derangement of this process so gas exchange is inadequate. Causes of respiratory failure are myriad, as are the causes of the clinical subset of respiratory failure cases that fall under the classification of adult respiratory distress syndrome.

In the clinical setting, respiratory failure is usually defined by arterial blood gas (ABG) values. A combination of hypoxia and hypercapnia (usually defined as $PO_2 < 60$ mm Hg and $PCO_2 > 50$ mm Hg in otherwise healthy individuals) indicates the presence of respiratory failure. In persons with chronic lung disease, more reliance must be placed on the clinical picture, as such patients may have preexisting ABG values outside the normal range. Some sources advocate basing the diagnosis of respiratory failure entirely on clinical criteria in these patients.[1,2]

The clinical presentation of respiratory failure varies with its underlying causes. Hypoxia is initially characterized by agitation and impaired judgment and may be mistaken for alcohol intoxication. More severe hypoxia may manifest as myocardial depression and cyanosis. Cyanosis may not be recognizable until the PO_2 is less than 40 mm Hg. The hallmarks of hypercapnia are confusion and drowsiness, with coma and death following if the situation is not rapidly corrected.

The first steps for treating respiratory failure are establishment and maintenance of a patent airway, whether orotracheal, endotracheal, or via tracheostomy. The second step is administration of oxygen. For patients breathing spontaneously, it may be done with any of several mask devices that provide varying concentrations of inspired oxygen. Patients who are intubated require mechanical ventilatory support while the underlying causes of the respiratory failure are elucidated and treated. All patients require intensive monitoring of their oxygenation and acid–base status, usually done via pulse oximetry and ABG sampling. Patients with underlying chronic obstructive lung disease may benefit from bronchodilator therapy (aminophylline and β-agonists) and corticosteroids.[1]

The prognosis for patients with respiratory failure depends on the etiology. If prompt treatment can reverse the underlying process, healthy lungs may recover. Lungs that are diseased do not have the regenerative powers found in normal lungs, and the prognosis is poor. In addition to intensively managing the patient's illness, the family physician is ideally suited to help the patient and family make informed decisions regarding treatment options.

Acute Respiratory Distress Syndrome

First described by Ashbauh et al. in 1967 as the adult respiratory distress syndrome (ARDS), this condition of acute respiratory failure is marked by severe hypoxemia, diffuse pulmonary infiltrates, poor lung compliance, and the absence of left heart failure.[3] The annual incidence in the United States is reported to be as high as 150,000 cases (0.6/1000 population), but controversy exists as to the validity of this figure.[4] Mortality rates range from 10% to 90%, but most series acknowledge more than 50% mortality.[5] The variation reported in incidence and outcome is in part due to the heterogeneity of conditions lumped together as ARDS. In 1993 the European American Consen-

R. B. Taylor et al. (eds.), *Family Medicine*

sus Committee on ARDS published guidelines for diagnostic criteria and relevant outcome markers to be used in future research. Recognizing its occurrence in children, the committee returned to the term *acute* (rather than *adult*) respiratory distress syndrome. Diagnostic criteria include timing (acute onset), oxygenation [$PaO_2/FIO_2 \leq 200$ mm Hg, regardless of positive end-expiratory pressure (PEEP) level], chest radiograph (bilateral infiltrates on frontal view), and hydrostatic pressure [mean airway pressure (Paw) ≤ 18 mm Hg, or no evidence of left atrial hypertension].[6]

The pathogenesis includes two pathways: direct effects of an insult on lung cells and the indirect result of an acute systemic inflammatory response, including both cellular and humoral components. These events lead to a final common pathway of injury to the alveolar-capillary barrier with increased vascular permeability, pulmonary edema, right-to-left shunting, progressive lung inflammation, reduction in surfactant, and alveoli collapse. Likewise, clinical settings in which patients are at risk for ARDS include both direct and indirect lung injury. The causes of ARDS are listed in Table 86.1. Infection has been found to be the most common cause, with sepsis accounting for as many as half of all cases.

The ARDS should be considered when any patient with one or more known causative factors develops dyspnea and tachypnea. Blood gases show decreased PO_2, with the PCO_2 normal or decreased. After initially responding to supplemental O_2 the patient becomes more dyspneic, and the hypoxia can no longer be corrected by giving O_2. Rales and bilateral interstitial infiltrates develop. At this point the patient requires ventilator management in an intensive care unit (ICU) setting with Swan-Ganz monitoring and involvement of a pulmonary or intensivist consultant, if available.

When treating ARDS, the goal is to support the lungs while correcting the underlying condition causing the direct or indirect lung injury. Although there are no randomized controlled trials to support any particular supportive modality as superior, mechanical ventilation, hemodynamic management, and prevention of secondary complications are the mainstays of therapy. Supplemental oxygen and positive-pressure mechanical ventilation are critical supportive therapies, although prolonged exposure to high oxygen concentrations can produce acute lung injury. Also, high transalveolar pressures can result in significant lung damage. Current strategies to accomplish adequate gas exchange while limiting FIO_2 and plateau pressures include the following: small tidal volumes (< 9 ml/kg while increasing the respiratory rate), optimal PEEP (5–15 cm H_2O), adjusting inspiratory and expiratory timing (increasing inspiratory times), and adjusting inspiratory flow pattern by using pressure-limited breaths.[7]

Novel therapeutic approaches to ventilation under investigation include extracorporeal membrane oxygenation, ventilation of liquid fluorocarbons to maintain the functional residual capacity (FRC), inhaled surfactant replacement, and inhaled nitric oxide. Systemic measures under study include monoclonal antibodies to endotoxin lipid A, monoclonal antibodies to tumor necrosis factor, nonsteroidal antiinflammatory drugs (NSAIDs), vasodilators, and antioxidant therapy with vitamin E, *N*-acetylcysteine, or superoxide dismutase.

Table 86.1. **Causes of Acute Respiratory Distress Syndrome**

Direct lung injury
- *Pneumonia*
  - Viral
  - Bacterial
  - Aspiration
    - Gastric contents
    - Fresh or salt water
- *Hydrocarbons*
- *Inhalation*
  - Oxygen
  - Smoke
  - Corrosive chemicals (e.g., NO, Cl, NH)
- *Chest trauma with lung contusion*
- *Radiation*
- *Embolism*
  - Fat
  - Amniotic fluid

Indirect lung injury
- *Sepsis*
- *Shock*
- *Major trauma*
- *Extensive burns*
- *Drugs*
- *Narcotics*
  - Sedatives
  - Aspirin (rare)
  - Thiazides (rare)
- *Metabolic disorders*
  - Pancreatitis
  - Uremia
- *Neurologic disorders*
  - Head trauma
  - Seizure
- *Intracranial bleeding*
- *Eclampsia*
- *Disseminated intravascular coagulopathy*
  - Cardiopulmonary bypass (rare)
  - Hypertransfusion for emergency resuscitation

Pulmonary Embolism

Pulmonary embolism is a frequent cause of morbidity and mortality but remains difficult to diagnose. It is thought that annually there are 2.5 million cases of deep vein thrombosis (DVT) leading to 650,000 to 700,000 cases of pulmonary embolism.[8]

Risk factors exist that make pulmonary embolism and DVT more likely (see Chapter 81). Hereditary risk factors include deficiencies of serum proteins that act as inhibitors of coagulation. Patients with these disorders present during early adulthood with thromboembolic events. Other risk factors include malignancy, congestive heart failure, obesity, estrogen therapy, prolonged anesthesia, orthopedic and pelvic surgery, and spinal and neurologic trauma. DVT may occur in as many as 20% to 30% of hospitalized high risk patients.[9,10]

Most pulmonary emboli originate from the deep veins of the thigh and pelvis. Thrombi usually develop from vein bifurcations or valve cusps; they may also arise in the calf but rarely embolize. DVT may arise in the upper extremity, with most cases seen in patients with central venous catheters, although spontaneous DVT of the upper extremity does occur.[11,12] Right atrial thrombus during atrial fibrillation is also a potential source.

Diagnosis

Deep vein thrombosis is difficult to diagnose. Many patients have no signs or symptoms. The most common clinical finding is unilateral leg edema, although dilated superficial veins, pain, cyanosis, and skin warmth may also be present. Evaluation may include venography, duplex ultrasonography, and impedance plethysmography. Venography can be used to evaluate the entire venous system, whereas the other methods evaluate only the proximal system and depend on operator skill and experience.[10,13]

Pulmonary embolus is similarly difficult to diagnose and may cause no signs or symptoms. It has become clear that most pulmonary emboli occur silently; in fact, half of the DVTs are found to have concurrent silent pulmonary emboli.[14,15] When pulmonary emboli occur, the presentation is variable; consequently, the diagnosis should be considered possible whenever a variety of cardiopulmonary disorders are suspected (Table 86.2).

Signs and symptoms of pulmonary emboli are inconsistent, and no finding or combination of findings is diagnostic. The most common symptoms are dyspnea, pleuritic pain, apprehension, and cough. Hemoptysis occurs in about one-third of patients. The most common signs are tachypnea, rales, increased P_2 heart sound, tachycardia, and fever. Only one-third of patients have clinically evident lower extremity phlebitis.

Table 86.2. **Disorders Often Confused With Pulmonary Embolism**

Pneumonia
Myocardial infarction
Congestive heart failure
Asthma
Chronic obstructive pulmonary disease
Unstable angina
Pleurisy/pleurodynia
Atrial arrhythmias

Evaluation for pulmonary embolism almost always includes a chest roentgenogram and an electrocardiogram (ECG), as they are obtained when other possible diagnoses are considered. The chest film usually is abnormal but nonspecific (e.g., showing pleural effusion, infiltrate, atelectasis, or elevation of the hemidiaphragm). The ECG is also often abnormal and nonspecific. Atrial arrhythmias (sinus tachycardia, atrial fibrillation), ST segment and T wave changes, and QRS changes are often found.[16,17]

Most patients with pulmonary embolism are hypoxic, although pulmonary emboli have been shown to occur in patients with a PO_2 of more than 90 mm Hg and a normal alveolar-arterial oxygen gradient. Age- and disease-related changes in normal arterial blood gases further limit their usefulness for diagnosing pulmonary embolism.[18]

Pulmonary ventilation-perfusion scanning or pulmonary angiography must be performed to establish the diagnosis of pulmonary embolism. Angiography should be used at the outset in patients at high risk of complications from anticoagulation, when massive pulmonary embolism is suspected, or when thrombolytic therapy might be undertaken. Ventilation-perfusion scanning may be used initially in other patients, but results must be interpreted carefully. A normal scan essentially rules out a pulmonary embolism. A high-probability scan (based on the size and number of unmatched perfusion defects) in any patient is correlated with an 88% chance of angiographically confirmed pulmonary embolism; in a patient clinically thought likely to have a pulmonary embolism, a high-probability scan is associated with a 96% chance of pulmonary embolism. Unfortunately, scans thought to represent low and intermediate probability are still associated with a significant percentage of pulmonary emboli (15% and 40%, respectively). Angiography may be pursued in any patient thought to have a pulmonary embolism based on clinical findings. Patients with either a positive angiogram or a "high risk" ventilation-perfusion scan should therefore be treated for pulmonary embolism.[19,20]

Prevention and Therapy

Prevention of thromboembolic disease can be accomplished in high risk patients. Pneumatic compression of the lower extremity provides some protection without bleeding risk. Subcutaneous heparin and oral warfarin are effective and have been used extensively in preoperative and high risk patients.[13] Enoxaparin is a low-molecular-weight heparin with similarly effective preventive properties. It retains the therapeutic effects of heparin with lower risks of adverse effects and less frequent dosing.[21,22] Some high risk trauma and neurosurgical patients have been shown to be most effectively treated with prophylactic inferior vena caval filters.[23]

Heparin therapy is effective therapy for initial therapy for both DVT and pulmonary embolism. A bolus of 5000 units IV is followed by a continuous infusion of

500 units/kg/day. This dosage should be adjusted to maintain a partial thromboplastin time of 1.5 to 2.0 times normal. Heparin should be continued 7 to 10 days to stabilize the thrombus; and during this time coagulation studies and platelets should be monitored daily. Heparin causes thrombocytopenia in up to 10% of patients.[13]

Thrombolytic therapy of pulmonary embolism may have some advantages over heparin therapy, particularly in critical patients with right ventricular dysfunction or hypotension. Pulmonary emboli resolve more rapidly with the thrombolytic therapy; moreover, improved blood flow and earlier clot lysis are noted. Disadvantages of thrombolysis include an increased risk of bleeding compared to heparin and allergic reactions.[24] Thrombolytic therapy should be considered in critical patients with proved emboli or as empiric therapy as a last ditch effort in patients for whom there is high clinical suspicion.[25]

Oral anticoagulation with warfarin may be instituted on the first or second day of treatment. Dosage should be adjusted to obtain a prothrombin time INR of 2.0 to 3.0.[13] The current recommendation for treatment is shorter than in the past. Medical patients should be treated for 3 months. Surgical patients may be treated 4 weeks if they are mobilized and no predisposing factors persist.[26] Warfarin has multiple drug interactions (e.g., with cimetidine, sulfonamides, carbamazepine, diuretics, and alcohol) and is contraindicated during pregnancy. Agents causing gastrointestinal bleeding should be avoided. Prolonged anticoagulation or an inferior vena caval filter should be considered for patients with recurrent thromboembolic events.[9,13] Pulmonary embolism can become chronic, leading to pulmonary hypertension and cor pulmonale.

Pulmonary Hypertension

There is no uniformly accepted hemodynamic definition of pulmonary hypertension; however, the U.S. National Institute of Health Primary Pulmonary Hypertension Registry requires a mean pulmonary pressure of more than 25 mm Hg at rest and 30 mm Hg during exercise as criteria for inclusion. Pulmonary hypertension develops when local physiologic conditions such as hypoxia and acidosis occur, leading to vasoconstriction and elevated pulmonary pressure. These and other mechanisms may play a role in the development of pulmonary hypertension secondary to other conditions, including surgical loss of pulmonary tissues, ventricular septal defect, left heart failure, obesity-hypoventilation syndrome, mitral valve disease, chronic obstructive lung disease, bronchial asthma, chronic thromboembolism, and interstitial fibrosis.[27,28]

Primary pulmonary hypertension is diagnosed when no other cause for elevated pulmonary artery pressure is found. Patients with this disorder present during young adulthood with exertional dyspnea, chest pain, and syncope.[29]

Chest roentgenograms may show "pruning" (decreased vascular working), increased right lower lobe pulmonary artery caliber, or increased pulmonary artery transhilar distance. The ECG may show right axis deviation or right ventricular hypertrophy. Both tests are frequently normal. Echocardiography can provide estimates of right ventricular pressures, but right heart catheterization is usually required for diagnosis. Ventilation-perfusion scans may help differentiate primary from secondary pulmonary hypertension.[30]

Identification of pulmonary hypertension requires a search for and treatment of secondary causes of the disorder. The aim of treatment is to prevent the development of cor pulmonale. Smoking cessation is clearly appropriate. With primary pulmonary hypertension, calcium channel blockers have been shown to improve pulmonary artery pressures and survival.[31] Anticoagulation is thought to prevent microthromboses, which may cause progression of the disorder. Warfarin has also been shown to improve survival.[31,32] Lung transplantation or heart–lung transplantation is appropriate for some patients.[32]

Pneumothorax

A pneumothorax is described as air entering the pleural space from either the lung or the chest wall and resulting in partial or total collapse of the affected lung. There are three types of pneumothorax.

Spontaneous Pneumothorax

Primary spontaneous pneumothorax occurs suddenly in healthy individuals (usually tall, thin men) and may be the result of a ruptured subpleural bleb. An increased incidence of spontaneous pneumothorax has been found among smokers and in certain families.[33,34] Secondary spontaneous pneumothorax is seen in patients with underlying lung disease, such as chronic obstructive pulmonary disease (COPD), tuberculosis, sarcoidosis, and cancer.

Clinical symptoms include sudden onset of chest pain on the side of the pneumothorax and dyspnea. Physical examination usually reveals normal vital signs except for a mild tachycardia. Breath sounds and tactile fremitus are absent or decreased on chest examination of the affected side, and ABG assays may reveal hypoxia. Patients with secondary spontaneous pneumothorax usually have more severe symptoms due to diminished baseline pulmonary function. Healthy individuals who have a small pneumothorax may present with mild symptoms and subtle physical findings.[34] The chest roentgenogram is diagnostic, showing a lucent area of pleural space devoid of the normal vascular markings that divides the edge of the lung from the chest wall.[33]

Treatment options depend on the size of the pneumothorax and the severity of symptoms. Small pneumothoraces, involving less than 15% of the hemithorax, usually

resolve without therapy. A large pneumothorax or a patient with severe symptoms requires removal of the air by insertion of a large-bore chest tube that allows reexpansion of the lung.

Recurrence rates for both types of spontaneous pneumothorax are around 50%, and the choice of treatment does not seem to affect these recurrence rates. Surgical or chemical pleurodesis is considered after two ipsilateral spontaneous pneumothoraces or when a 5- to 7-day course of chest tube therapy fails to result in lung reexpansion.[34]

Traumatic Pneumothorax

A traumatic pneumothorax can result from penetrating or nonpenetrating chest trauma as well as from such invasive procedures as bronchoscopy, thoracentesis, central line placement, mechanical ventilation, and cardiopulmonary resuscitation. Most traumatic pneumothoraces seen in hospitals today are iatrogenic due to numerous invasive procedures. The symptoms, physical examination, and radiologic findings are similar to those of spontaneous pneumothorax. Treatment depends on the size of the pneumothorax and symptoms. Traumatic pneumothoraces resulting from direct trauma require tube thoracostomy, as a hemothorax is often present.[33,34]

Tension Pneumothorax

A tension pneumothorax can result from either a spontaneous or a traumatic pneumothorax and is a life-threatening emergency. Tension develops as air freely enters the pleural space during inspiration but is unable to escape during expiration. The result of this one-way valve is further lung collapse, with shifting of the trachea and mediastinum away from the pneumothorax. Patients with a tension pneumothorax are in acute respiratory distress and have dilated neck veins, tracheal deviation, and absence of breath sounds on the affected side. They are in danger of impending cardiovascular collapse unless prompt treatment ensues. Immediate insertion of a large-bore (16 gauge) needle into the affected pleural cavity at the second intercostal space releases the trapped air, relieves the pressure, and results in rapid improvement in cardiac output and blood pressure. Following this emergent procedure, a chest roentgenogram can be obtained and a chest tube inserted to prevent recurrence.[33,34]

Pleural Effusion

A pleural effusion is defined as an accumulation of fluid in the pleural space that occurs as a result of disparity between fluid formation and resorption. It is not a disease but may be a result of more than 50 disease processes. Six diseases—congestive heart failure (CHF), cirrhosis with ascites, pleuropulmonary infections, malignancy, pulmonary embolism, and pancreatitis—account for more than 90%. By using the history, physical findings, and thoracentesis to sample and analyze the pleural fluid, the physician can establish the etiology in approximately 75% of cases.[35–37]

Patients with pleural effusions may be asymptomatic, although some present with pleuritic chest pain, dyspnea, cough, and fever. Physical examination of the chest reveals decreased breath sounds and tactile fremitus, dullness to percussion, and a pleural friction rub.

The chest roentgenogram often confirms the presence of an effusion with blunting of the diaphragm and costophrenic angle noted in the involved hemithorax. Lateral decubitus views and ultrasonography may reveal smaller effusions that are often not apparent on the upright chest film.[33,38]

Once a pleural effusion is confirmed, the etiology is sought. Pleural fluid obtained by thoracentesis can be analyzed to help determine the cause of the effusion. The fluid can then be categorized as either a transudate or exudate based on analysis of several simple laboratory tests outlined in Table 86.3. There are other pleural tests that may aid in the diagnosis, including cytology, glucose assay, Gram stain, bacterial and fungal cultures, acid-fast bacillus (AFB) stain, amylase assay, rheumatoid factor assay, and lipid studies; these tests should be performed based on the nature of the fluid and the clinical presentation.[37,39] It is of note that pleural tuberculosis can be diagnosed using adenosine deaminase as a pleural fluid marker.[36]

The major causes of a transudative effusion are CHF (most common), cirrhosis, nephrotic syndrome, and hypoalbuminemia. The most common groups causing exudative effusions are infection (most commonly bacterial pneumonia and tuberculosis), pulmonary embolism, neoplasms, collagen vascular diseases, pancreatitis, and other intraabdominal diseases.[3,26,27] Numerous authorities have

Table 86.3. **Pleural Fluid Characteristics**

Characteristic	Transudate	Exudate
Pleural fluid/serum protein ratio	< 0.5	> 0.5
Pleural fluid/serum LDH ratio	< 0.6	> 0.6
Pleural fluid LDH	Less than two-thirds of upper limit of normal serum LDH	More than two-thirds of upper limit of normal serum LDH
pH	> 7.40	< 7.40
WBC count	Usually < 1000/μl	Usually > 1000/μl

suggested that a transudative pleural effusion requires no further evaluation.[37,39]

Treatment of a pleural effusion should be directed at the underlying disease process. Appropriate antibiotic therapy usually results in resolution of a parapneumonic pleural effusion, although some effusions require chest tube drainage. Pleurodesis is used for management of recurrent malignant effusions and for transudative effusions that do not respond to maximal medical treatment.[36]

Many pleural effusions reflect chronic disease, thereby requiring family education and physician support. Hospice care may be beneficial for the terminal patient and his or her family. Some infectious diseases such as tuberculosis require that the family physician screen and treat family members (see Chapter 84).

Interstitial Lung Disease

The interstitial lung diseases (ILDs) are a group of heterogeneous disorders that are classified together because of similar clinical, pathologic, physiologic, and roentgenographic findings. In the United States the prevalence of ILD is estimated to be 20 to 40 per 100,000 population.[40]

Interstitial lung diseases have common histologic findings, including derangement of the alveolar structures in the lung with inflammation (alveolitis) and fibrosis of the alveolar walls, air spaces, and pulmonary capillaries. Because the alveoli are frequently involved, the term chronic diffuse infiltrative lung disease has been proposed as more accurate.[38,41] The initiating agent is unknown in most cases but is thought to be a toxin or antigen, which leads to alveolitis and fibrosis. These changes result in decreased lung compliance and volumes as well as limited transfer of oxygen from air to blood.

More than 150 ILDs have been identified and are classified by etiology. Sixty-five percent of them have an unknown etiology, with the remainder being known. A smaller group is responsible for most of the clinical cases. Table 86.4 is an abbreviated list of the more commonly seen ILDs.

Table 86.4. **Some Common Interstitial Lung Diseases**

Known etiology
Inhaled inorganic dusts
Silicosis
Asbestosis
Coal worker's pneumoconiosis
Berylliosis
Hypersensitivity pneumonitis
Farmer's lung
Drug-induced
Cytotoxic drugs
Nitrofurantoin
Amiodarone
Gold
Penicillamine
Radiation pneumonitis
Unknown etiology
Sarcoidosis
Collagen vascular disorders
Systemic lupus erythematosus
Rheumatoid arthritis
Idiopathic pulmonary fibrosis
Eosinophilic pneumonitis
Histiocytosis X
Pulmonary hemorrhage syndrome

The predominant clinical symptoms are cough and breathlessness. Typically, patients exhibit insidious exertional breathlessness, dry cough, fatigue, and malaise. Less frequent complaints include chest pain, hemoptysis, fever, anorexia, and weight loss. A detailed history is the most useful diagnostic tool and should include questions about the duration and progression of symptoms, the presence of fever or other constitutional symptoms, a comprehensive occupational history, a review of medications, and symptoms of or exposure to the human immunodeficiency virus (HIV). Physical examination may reveal bibasilar dry rates (often described as Velcro-like), clubbing, and cyanosis; the examination may also be normal.

Chest roentgenography may reveal a diffuse interstitial, alveolar, or mixed pattern in the lung fields that often progresses to a "honeycomb" pattern. A normal chest film is present in 10% of patients despite significant clinical disease. ABGs may be normal or show a mild hypoxemia that worsens with exercise. Hypercarbia is rare, and hypocarbia may be present. Most laboratory studies are normal except for an often elevated erythrocyte sedimentation rate. Pulmonary function tests demonstrate a restrictive pattern with reduced vital capacity, diffusing capacity, and total lung volume as well as a normal or above normal forced expiratory volume at 1 minute/forced vital capacity ratio (FEV_1/FVC).[33]

Open lung biopsy is usually required to establish the diagnosis. Transbronchial biopsy and bronchoalveolar lavage can sometimes be used to establish the diagnosis and cause of the ILD but are not as helpful.[42] Gallium 67 lung scans can be used to assess the disease activity and treatment response but are of limited use diagnostically.

The goal of the treatment in ILD is to suppress the alveolitis and prevent further lung damage.[43,44] Untreated, most ILDs progress to end-stage lung disease with cor pulmonale and death due to respiratory failure. The mainstay of treatment for ILDs of unknown etiology is corticosteroids to decrease the inflammation. Immunosuppressive and cytotoxic agents have also been used. Bronchodilators and oxygen therapy are often useful during the later stages of the disease. With known ILDs, initial treatment begins with identification and removal of the causative agent, followed by corticosteroids if the inflammation fails to resolve.

All patients with ILD are susceptible to bacterial lung infections and must be monitored closely. Smoking cessation and avoidance of bystander smoke should be encouraged.

Pulmonary Sarcoidosis

Sarcoidosis is a multisystem granulomatous disease of unknown etiology that affects all race and age groups but most commonly affects black women age 20 to 40 years. Pulmonary involvement is by far the most frequent clinical problem and is responsible for the bulk of the morbidity and mortality. Granulomas form in the alveoli, bronchi, and pulmonary vessels, leading to derangement of pulmonary function.

The most frequent symptoms are dyspnea and cough. Patients may present initially with nonpulmonary symptoms such as fever, arthralgias, malaise, and erythema nodosum. However, patients with sarcoidosis are frequently asymptomatic and are identified on the basis of abnormalities on a chest roentgenogram performed for other reasons.[45] The most common radiographic findings are bilateral hilar lymphadenopathy and diffuse infiltrates. Ninety-five percent or more of patients have some abnormality on the chest radiograph. Diffusing capacity and vital capacity are generally adversely affected.

It is important to distinguish pulmonary sarcoidosis from other granulomatous diseases and other infiltrative lung diseases that may have identical clinical presentations. Bronchoscopy with transbronchial lung biopsy is the preferred diagnostic modality.[46] Serum angiotensin-converting enzyme levels are elevated in 80% of patients and may aid in diagnosis.[47]

The course of sarcoidosis is variable, with some patients experiencing resolution of all symptoms and others having slowly progressive disease. Corticosteroids effectively relieve symptoms but have not been shown to modify the overall course of the disease. For this reason, treatment with corticosteroids is usually reserved for patients with worsening symptoms or "organ-threatening" pulmonary or extrapulmonary disease. The usual treatment for symptomatic sarcoidosis is prednisone 40 to 60 mg/day with slow tapering of the dose over several months. The patient may then be maintained on lower doses as required; a typical dose might be 10 to 20 mg/day or every other day for as long as a year. Unfortunately, as many as two-thirds of patients relapse after termination of treatment.

Atelectasis

Atelectasis, or lung collapse, has two common types. Subsegmental and lobar atelectasis are defined by their clinical findings and radiographic appearance.

Subsegmental (plate-like) atelectasis can be asymptomatic or present with cough, sputum production, fever, dyspnea, tachypnea, and end-inspiratory crackles. Radiographs show linear densities in the lower lung fields. Early postoperative fever does not correlate well with atelectasis.[48,49] Risk factors for atelectasis are abdominal or chest surgery (23% abdominal, 44% laparoscopic cholecystectomy, 54–100% coronary artery bypass), inadequate preoperative education, chronic lung disease ($FEV_1 < 1.5$ liter), smoking, obesity, cardiac disease, age over 55, recent respiratory infection, muscle weakness, excessive secretions, inadequate postoperative pain relief, and sickle cell crisis. In the postoperative setting other pulmonary complications (pulmonary embolus, aspiration, pneumonia, bronchospasm) should be considered, especially if associated with pleuritic chest pain, hemoptysis, hypoxia, hypoventilation, or fever.

During the perioperative period, pre- and postoperative deep breathing and coughing and postoperative postural drainage have been shown to reduce atelectasis from 42% to 12%.[50] Early ambulation, voluntary deep-breathing exercises (sustained maximum inspiration with incentive spirometry: 10 deep breaths with a 3- to 5-second inspiratory hold every 1 to 2 waking hours) reduces pulmonary morbidity. At the preoperative physical examination the family physician must explain the importance of these maneuvers to the patient and enlist family members for compliance supervision. Smoking cessation at least 2 months prior to elective procedures if possible should be stressed. Intermittent positive-pressure breathing is not effective.[51]

Lobar atelectasis produces dullness to percussion, with decreased vocal fremitus and breath sounds over the effected lobe. The radiograph may show elevation of the hemidiaphragm, displacement of fissures and hilum, and shift of the mediastinum toward the collapsed lobe with homogeneous consolidation of the affected lobe. Lobar atelectasis in infants most often involves the right upper lobe. Children are more likely to collapse the left lower or right middle lobe. Most of these problems are postpneumonic and usually clear within a few weeks to 3 months. Other considerations in the differential diagnosis of lobar collapse in children are foreign body aspiration (more commonly causes hyperinflation, 40% have atelectasis), congenital malformations of the bronchial skeleton, external compression from vascular or other structures, and chronic inflammation. Recurrent collapse is common in those with asthma or cystic fibrosis. In adults malignancies and asthma are common. Atelectasis should be considered when there is worsening oxygenation on mechanical ventilation.

Treatment of lobar collapse requires attention to the diagnosis and management of underlying disease. Chest percussion and postural drainage with the assistance of a respiratory therapist or family members can be beneficial. Bronchoscopy is helpful for foreign body removal, persistent collapse not responsive to conservative measures, definitive diagnosis, and direct laser treatment of obstructive lesions.

Other forms of atelectasis are the patchy atelectasis of infectious pneumonia in toddlers, which usually clears with treatment. Rounded atelectasis is an uncommon peripheral pseudotumor, 87% of which are related to asbestos exposure.[52] Widespread diffuse atelectasis due to inadequate surfactant occurs in the premature infant with respiratory distress syndrome or from the lung injury of vapor or smoke inhalation.

Hyperventilation

Hyperventilation may be due to drug effects, alcohol withdrawal, central nervous system (CNS) lesions, asthma, heart failure, pulmonary embolus, acclimatization to high altitude, heat, exercise, pregnancy, chronic pain, or psychogenic causes. Other causes of hyperventilation can usually be excluded by the history and physical examination. Hyperventilation syndrome (HVS), the most common presentation, is psychogenic and often ill-defined (see Chapter 31). Risk factors for HVS are perfectionism, a family or personal history of anxiety or depression, grief, resentment, fear of serious illness, marital discord, living alone, and secondary gain.[53] Symptoms of HVS are episodic shortness of breath often at rest, air hunger or inability to take a deep breath, chest pain, palpitations, cold extremities, dizziness, lightheadedness, paresthesia (circumoral or acral), tremor, sickness, abdominal distension, fatigue, hot sensations, diaphoresis, chills, feelings of unreality, and dry mouth. Signs may be absent, but prominent upper thoracic movement, lack of costal expansion, decreased diaphragmatic breathing, and sighs and gasps may be noted. Voluntary breath-holding time is often abnormally short (< 10 seconds). The diagnosis is based on the above clinical findings and reproduction of symptoms during a hyperventilation provocation test done by having the patient take 20 deep breaths per minute for 3 minutes. The test gives false-positive and false-negative results, so reproducibility is inconsistent; the test is avoided in persons with known ischemic heart disease.

Treatment focuses on the patient recognizing that hyperventilation causes the symptoms. Controlled diaphragmatic breathing and relaxation training[54,55] can be taught to the patient by the family physician and behavioral therapist. Associated anxiety disorders and depression may require behavioral or medical treatment.

Bronchiectasis

Bronchiectasis is the irreversible widening of small airways. Often a significant lung injury such as pneumonia (bacterial, tuberculosis, pertussis) or foreign body aspiration precedes symptoms by 10 to 20 years. Cystic fibrosis, *Mycobacterium avium-intracellulare* disease, bronchopulmonary aspergillosis, immotile cilia syndrome, α_1-antitrypsin deficiency, hypogammaglobulinemia, rheumatoid arthritis, Sjögren syndrome, and Kartagener syndrome are other predisposing diseases.

Bronchiectasis presents with chronic productive cough (purulent, noncopious, non-foul-smelling, and often worse after lying down). Other findings are dyspnea, recurrent fever and pleurisy, hemoptysis, and sputum production with upper respiratory infections only. Common signs are crackles, squeaks, rhonchi, and wheezing.[56] Lung sounds may vary with cough and posture or be localized and persistent. Different from other chronic lung disease is its occurrence in nonsmokers, its predominance in women (70%), and chest radiographic abnormalities (91%) that show patchy chronic or recurrent infiltrates or dilated, thickened airways (parallel lines, ring shadows in cross section) sometimes with air-fluid levels. If doubt remains, high resolution CT is diagnostic.

Management includes pneumococcal and influenza vaccination, treatment of any underlying disease (e.g., gamma globulin replacement for hypogammaglobulinemia), chest physiotherapy three or four times daily, antimicrobial therapy of exacerbations or prophylaxis[57] (amoxicillin, tetracycline, or trimethoprim-sulfamethoxazole as first line drugs to cover *Haemophilus influenzae* and *Streptococcus pneumoniae*), aerosolized bronchodilators and antiinflammatory agents, oxygen (PO_2 < 55 or symptomatic right heart failure), arterial embolization for life-threatening hemoptysis, and surgery for those who have failed conservative therapy or have localized disease.

References

1. Rosen RL. Acute respiratory failure and chronic obstructive lung disease. Med Clin North Am 1986;70:895–970.
2. Petty TL. Acute respiratory distress syndrome (ARDS). Dis Mon 1990;36:1–58.
3. Ashbauh DG, Bigelow DB, Petty TL, Levine BE. Acute respiratory distress in adults. Lancet 1967;2:319–23.
4. Villar J, Siltsky AS. The incidence of adult respiratory distress syndrome. Am Rev Respir Dis 1989;140:814–16.
5. Suchyta M, Clemmer T, Elliott C, Orme J, Weaver L. The adult respiratory distress syndrome: a report of survival and modifying factors. Chest 1992;101:1074–9.
6. Bernard GF, Artigas KL. Report of the American-European consensus conference on ARDS; definitions, mechanisms, relevant outcomes and clinical trial coordination. Intensive Care Med 1994;20:225–32.
7. Fulkerson WJ, Neil M, Stampler J, Crapo JD. Pathogenesis and treatment of adult respiratory distress syndrome. Arch Intern Med 1996;156:29–38.
8. Ansaria A. Acute and chronic thromboembolism: current perspectives. Part 1. Glossary of terms, historic evaluation and prevalence. Clin Cardiol 1986;9:398–402.
9. Bowen KJ, Vukelja SJ. Hypercoagulable states—their causes and management. Postgrad Med 1992;91:117–32.
10. Stephen JM, Feied CF. Venous thrombosis. Postgrad Med 1995;97(1):36–47.
11. Horattas MC, Wright DJ, Fenton AH, et al. Changing concepts of deep vein thrombosis of the upper extremity: report of a series and review of the literature. Surgery 1988;104: 561–7.
12. Monreal M, Lafox E, Rulz J, Valls R, Alastrue A. Upper extremity deep vein thrombosis and pulmonary embolism. Chest 1991;99:280–3.

13. Gray BH, Craor RA. Deep vein thrombosis and pulmonary embolism. Postgrad Med 1992;91:207–20.
14. Huisman MV, Buller HS, Carte JW, et al. Unexpected high prevalence of silent pulmonary embolism in patients with deep vein thrombosis. Chest 1989;96:498–502.
15. Nelson HK, Husted SE, Krussell IR, Fasting H, Charles P, Hansen HH. Silent pulmonary embolism in patients with deep vein thrombosis. J Intern Med 1994;235:457–61.
16. Bell WG, Simon TL, DeMets DL. The clinical features of submassive and massive pulmonary emboli. Am J Med 1977;62:355–60.
17. Fulkerson WJ, Coleman RE, Raven VE, Saltman HA. Diagnosis of pulmonary embolism. Arch Intern Med 1976;146: 961–7.
18. Overton DT, Bocka JJ. The alveolar-arterial oxygen gradient in patients with documented pulmonary embolism. Arch Intern Med 1988;45:1617–19.
19. Hull RD, Hirsh J, Carter CT, et al. Pulmonary angiography, ventilation lung scanning and venography for clinically suspected pulmonary embolism with abnormal perfusion lung scan. Ann Intern Med 1983;98:891–9.
20. PIOPED Investigators. Value of the ventilation/perfusion scan in acute pulmonary embolism: results of the prospective investigation of pulmonary embolism diagnosis (PIOPED). JAMA 1990;263:2753–9.
21. Ament PW, Bertolino JG. Enoxaparin in the prevention of deep vein thrombosis. Am Fam Physician 1994;50:1763–8.
22. Turple AG. Deep vein thrombosis prophylaxis in the out-patient setting; preventing complications following hospital discharge. Orthopedics 1995;18 Suppl:15–17.
23. Khansarinin S, Dennis JW, Veldenz HC, Butcher JL, Hartland L. Prophylactic greenfold filter placement in selected high-risk trauma patients. J Vasc Surg 1995;22:231–6.
24. Goldhaber SZ. Thrombolytic therapy in venous thromboembolism: clinical trials and current indications. Clin Chest Med 1995;2:307–20.
25. Handler JA, Feied CF. Acute pulmonary embolism: aggressive therapy with anti-coagulant and thrombolytics. Postgrad Med 1995;97(1):61–72.
26. Tyrell MR, Birtie AJ, Taylor PR. Deep vein thrombosis. Br J Clin Pract 1995;49:252–6.
27. Murray JF, Rubin LJ. Textbook of respiratory medicine. 2nd ed. Philadelphia: Saunders.
28. Rich S, Dantzler DR, Ayres SM, et al. Primary pulmonary hypertension: a national prospective study. Ann Intern Med 1987;107:216–23.
29. Rubin L. Pathology and pathophysiology of primary pulmonary hypertension. Am J Cardiol 1995;75(3):51A–54A.
30. Moser KM, Page GT, Ashburn WL, Fedullo PF. Perfusion scans provide a guide to which patients with apparent primary pulmonary hypertension merit angiography. West J Med 1988;148:167–70.
31. Rich S, Kaufman E, Levy S. The effect of high dose calcium channel blockers on survival in primary pulmonary hypertension. N Engl J Med 1992;327:76–81.
32. Rich S. Medical treatment of primary pulmonary hypertension: a bridge to transplantation? Am J Cardiol 1995;75(3): 63A–69A.
33. Weinberger SE. Principles of pulmonary medicine. 2nd ed. Philadelphia: Saunders, 1992.
34. Jenkinson SG. Pneumothorax. Clin Chest Med 1985;6:153–61.
35. Jay SJ. Diagnostic procedures for pleural disease. Clin Chest Med 1985;6(1):33–48.
36. Feinsilver SH, Houston MC, Sahn SA. Fast-track effusion care. Patient Care 1992;26(3):92–133.
37. Sahn SA. State-of-the-art: the pleura. Am Rev Respir Dis 1988;138:184–234.
38. Henschkle CI, Davis SD, Remeno PM, Yankelevitz DF. The pathogenesis, radiologic evaluation, and therapy of pleural effusions. Radiol Clin North Am 1989;27:1241–55.
39. Peterman TA, Speicher CE. Evaluating pleural effusions: a two-stage laboratory approach. JAMA 1984;252:1051–3.
40. Crystal RG, Gadek JE, Ferrans VJ, Fulmer JD, Line BR, Hunninghake GW. Interstitial lung disease: current concepts of pathogenesis, staging and therapy. Am J Med 1981;70:542–68.
41. Staton GW, Ingram RH. Diffuse parenchynal lung disease. Sci Am Med 1994;14:Sec V.
42. Bensard DD, McIntyre RC Jr, Waring BJ, et al. Comparison of video thorascopic lung biopsy to open lung biopsy in the diagnosis of interstitial lung disease. Chest 1993;103–765.
43. Rulmer JD. An introduction to the interstitial lung diseases. Clin Chest Med 1982;3:457–70.
44. Fulmer JD. The interstitial lung diseases. Chest 1982;82:172–8.
45. DeRemee RA. Diffuse interstitial pulmonary disease from the perspective of the clinician. Chest 1987;92:1068–73.
46. Teirstein AS. Fiberoptic bronchoscopy in the diagnosis of sarcoidosis: sarcoidosis and other granulomatous diseases of the lung. In: Fanburg BC, editor. Lung biology in health and diseases. New York: Marcel Dekker, 1983.
47. Rohrbach MS, DeRemee KA. Pulmonary sarcoidosis and serum angiotensin converting enzyme. Mayo Clin Proc 1982;57:64.
48. Johnson NT, Pierson DJ. The spectrum of pulmonary atelectasis: pathophysiology, diagnosis, and therapy. Respir Care 1986;31:1107–20.
49. Department of Anesthesia, St. Vincent Medical Center, Toledo, OH. Lack of association between atelectasis and fever. Chest 1995;107(1):81–4.
50. Thoren L. Postoperative pulmonary complications and their prevention by means of physiotherapy. Acta Chir Scand 1954;107–93.
51. Brooks-Brunn JA. Postoperative atelectasis and pneumonia. Heart Lung 1995;24:94–115.
52. Hillerdal G. Rounded atelectasis: clinical experience with 74 patients. Chest 1989;95:836–41.
53. Howell JBL. Behavioral breathlessness. Thorax 1990;45:287–92.
54. Garssen B, Rijken H. Clinical aspects and treatment of the hyperventilation syndrome. Behav Psychother 1986;14:46–68.
55. Hegel MT, Abel GG, Etscheidt M, Cohen-Cole S, Wilmer CI. Behavioral treatment of angina like chest pain in patients with hyperventilation syndrome. J Behav Ther Exp Psychiatry 1989;20:31–9.
56. Nicotra MB, Rivera M, Dale AM, et al. Clinical, pathophysiologic, and microbiologic characterization of bronchiectasis in an aging cohort. Chest 1995;108:955–61.
57. Stockley RA. Bronchiectasis: new therapeutic approaches based on pathogenesis. Clin Chest Med 1987;8:481–93.