Pneumonia

Pearls for interpreting patients' radiographs

Although a chest radiograph is essential in confirming suspect- ed pneumonia and establishing its location, it cannot determine the cause. Pneumonia is a serious disease, and most patients and physicians want to start treatment without waiting for laboratory identification of the specific infecting organism. In this article, Dr Montgomery provides the means of making an educated preliminary diagnosis on the basis of radiographic patterns of infiltration and other clues in the radiographic picture.

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Pneumonia is the sixth leading cause of death in the United States and ranks fourth among men and fifth among women as the cause of hospitalization. Among patients under age 15, it is the most frequent cause of hospitalization. Several factors are responsible for pneumonia's continued high mortality rate: aging of the US population (advanced age increases susceptibility), greater numbers of immunocompromised hosts, increased frequency of antibiotic- resistant organisms, and ongoing association with underlying illnesses (eg, chronic obstructive pulmonary disease, alcoholism, cancer).

The plain chest film is the imaging procedure of choice for detecting pneumonia and is the cornerstone of diagnosis. Examination with a stethoscope is less sensitive. Osmer and Cole reported that auscultatory evidence of pneumonia was absent in one fourth of patients during their illness and that radiographic and stethoscopic findings commonly did not agree.

The primary role of the chest radiograph is to differentiate pneumonia from other conditions that produce opacities (eg, atelectasis, pleural effusion, pulmonary embolus, aspiration, pulmonary contusion, mass lesions). The chest radiograph is also helpful in following the progress of pnei1monia, evaluating the response to therapy; and detecting complications (eg, pleural effusion, empyema, congestive heart failure).

Although the chest film is sensitive in identifying pneumonia, it does not establish a specific type. Obviously, the causative organism must be determined by laboratory evaluation, but before specific laboratory information becomes avail- able, a presumptive diagnosis of the type of pneumonia present can be made on the basis of clinical information, epidemiologic factors, and classic radiographic signs. An abnormal radiographic pattern combined with pertinent information (eg, patient's age, clinical setting in which infection occurs) suggests the proper diagnosis with a reasonable degree of reliability: Thus, appropriate treatment can be initiated immediately.

Often, the cause of pneumonia is indeterminable even after laboratory testing, so antibiotic selection is based on clinical and radiographic features. Since clinical features are often indistinctive, the radiographic appearance of pneumonia serves as the primary guide to therapy.

Terminology

An understanding of terms commonly used to describe radiographic findings is essential in interpreting the radiography report and in making an accurate radiographic diagnosis of pneumonia. The Fleischner Society, a multidisciplinary group organjzed to promote exchange of information between scientists and clinical investigators interested in disorders of the chest, developed a glossary of radiographic terms.

The Fleischner Society developed a glossary to help describe and improve recognition of pulmonary disorders.

Commonly used terms in pulmonary radiography:

Acinar pattern- Collection of round poorly defined discrete or partially confluent opacities in lung.

Acinar Shadow- Round or ovoid poorly defined pulmonary opacity to 8mm in diameter, presumed to represent anatomic acinus rendered opaque by consolidation.

Acinus- Lung that is distal to terminal brochiole, consisting of respiratory bronchioles, alveolar ducts andsacs, alveoli and their blood vessels, lymphatics, and supporting tissues.

Air bronchogram- Radiographic shadow of air-filled bronchus peripheral to the hilum and surrounded by airless lung.

Airspace- Gas containing part of lung including respiratory bronchioles but excluding purely conductive airways.

Coalescence- Replacement of air in lung with products of disease, rendering the lung solid.

Infilitrate – Foreign substance or cell that accumulates in greater than normal quantity through the intestitium and/or alveoli.

Interstitium- Continuum of loose connective tissue throughout lung.

Lobule- Unit of lung structure usually used to refer to variable number (generally 3 to 5) of acini bounded by thin connective tissue septa (ie, secondary pulmonary lobule).

The secondary pulmonary lobule is a basic unit of lung structure and function.
It contains a variable number of pulmonary acini.

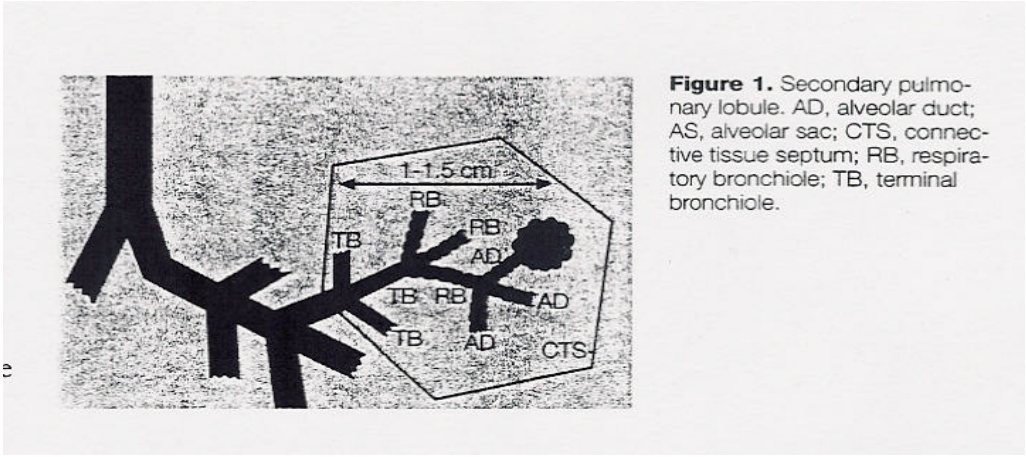

Figure 1. Secondary pulmonary lobule. AD, alveolar duct; AS, alveolar sac; CTS, connective tissue septum; RB, respiratory bronchiole; TB, terminal bronchiole.

Knowledge of these terms greatly improves the understanding of pneumonia and other pulmonary conditions. Some terms commonly used in the description of pneumonia are defined in the box on page 60.
The terms "opacity" and "density" are both used to describe shadows in the lungs that are more white than surrounding lung. "Opacity" is the preferred term for describing the radiographic patterns of pneumonia. Nebulous terms that have little meaning, such as "increased bronchovascular markings," should be avoided.

An understanding of the terms "secondary pulmonary lobule" and "pulmonary acinus" is helpful in evaluating the opacities that are visualized on radiographs.
The secondary pulmonary lobule (figure 1) is important in defining the radiographic patterns of pneumonia. This basic unit of lung structure and function consists of three to five terminal bronchioles and measures about 1 to 1.5 cm in diameter. The primary pulmonary lobule is a subunit of the secondary pulmonary lobule, and this term has been largely abandoned.

The pulmonary acinus (figure 2) is the portion of the lung that is distal to a terminal bronchiole and includes respiratory bronchioles, alveolar ducts, and alveolar sacs. Alveoli . project from the walls of the alveolar sacs and ducts. The pulmonary acinus represents the smallest airspace unit that is visible on radiographs

and measures 4 to 8 mm in diameter. The secondary pulmonary lobule contains a variable number of pulmonary acini.

Airspace disease is a collection of acinar shadows containing fluid. A single acinar shadow is seldom seen on radiographs, and airspace disease represents an aggregate of these shadows. These shadows are fluffy, irregular areas of opacification that may coalesce to form an area of con- solidation. Alveolar filling disease may appear on radiographs as patchy areas of opacification restricted to the secondary lobules or as lobar consolidation. Airspace disease is not specific for pneumonia and may be produced by any fluid within the airspaces, including exudates, transudates, and blood.

Secondary pulmonary lobules are separated from each other by connective tissue

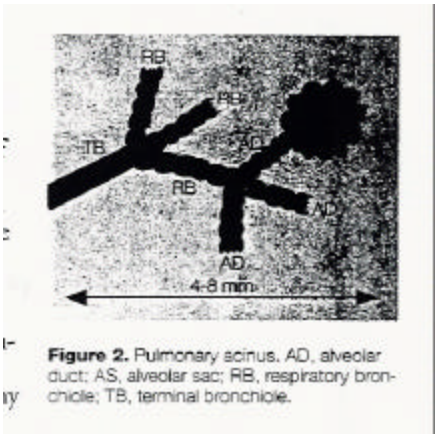

Figure 2. Pulmonary acinus. AD, alveolar duct; AS, alveolar sac; RB, respiratory bronchiole; TB, terminal bronchiole.

septa. Interstitial processes involve thickening of the interlobular septa and cause linear and reticular shadows on radiographs. Interstitial disease may be nonspecific and is produced by numerous interstitial processes, such as fibrosis, in addition to pneumonia. Acute interstitial infiltrates are usually produced by edema or pneumonia.

Radiographic patterns

Pneumonias are usually classified and described according to the causative organism. However, in initial evaluation of the radiograph, when the organism is unknown, this approach is of limited value. Classification according to morphologic changes in the lungs aids initial evaluation by suggesting the most likely offending organism and by limiting diagnostic possibilities. Occasionally, classic radiographic signs that suggest a specific diagnosis are present, bur usually the best that can be achieved is a differential diagnosis suggested by the pattern present.

Pneumonias involve the airspaces, interstitium, or a combination of the two. Analysis of an infiltrate on the radiograph is aided by determining the type of morphologic change in the secondary pulmonary lobule. Heirzman has described three basic morphologic, or radiographic, patterns produced by pneumonia: lobar, lobular (bronchopneumonia), and interstitial.

Figure 3. Lobar pattern of infiltration with air bronchograms in pneumococcal pneumonia.

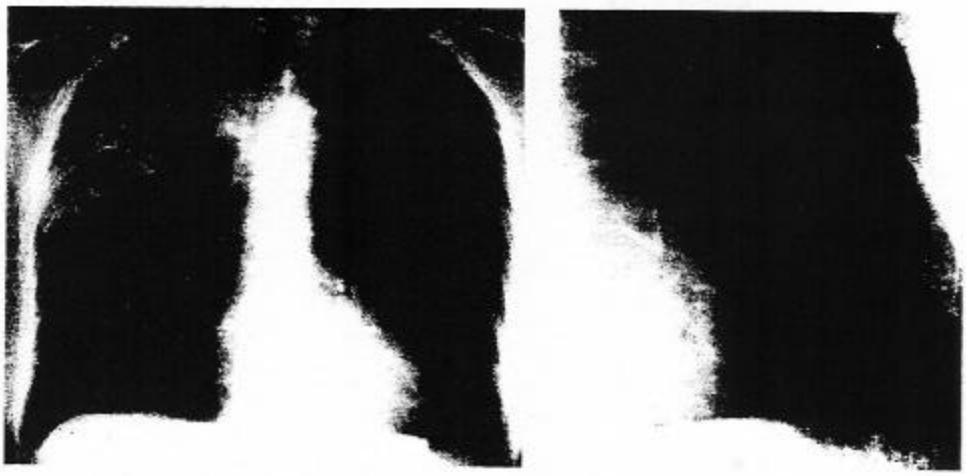

Figure 5. Interstitial pattern of pneumonia, with reticular infiltrate.

In lobar pneumonia, organisms damage the terminal airspaces, resulting in an outpouring of edema fluid into the alveoli.

LOBAR- Organisms damage the terminal airspaces, resulting in an outpouring of edema fluid into the alveoli, in the lobar pattern of pneumonia (figure 3). Alveolar fluid becomes infected and spreads throughout a lobe by way of the pores of Kohn and the canals of Lambert. Consolidation that results from this spread of infected fluid respects pleural boundaries. Air bronchograms are seen within the opacification and are a distinguishing feature of airspace disease.

Pneumococcal pneumonia is the most common community-acquired infection to produce the lobar pattern. *Klebsiella* is also a common causauve organism.

LOBULAR- Organisms damage the walls of terminal and respiratory bronchioles in the lobular pattern of pneumonia (figure 4). Infection spreads along the intralobular airway until the pulmonary lobule is partially or totally involved. This process tends to respect the septal boundaries that surround the secondary pulmonary lobule. The resulting radiographic pattern is a poorly defined, fluffy or patchy opacity; Opacities are scattered in the involved area of the lung and may become confluent, in which case a lobular pattern of pneumonia cannot be distinguished from a lobar process.

Many organisms produce the lobular pattern, including *Staphyl coccus,* gram-negative pathogens, and e anaerobes.

INTERSTITIAL- Organisms damage the bronchiolar wails and destroy mucosal cells in the interstitial pattern of pneumonia (figure 5). Airway wails become edematous, and cellular infiltrates develop and spread to peribronchial tissues and interlobular septa. Linear, reticular, and smail nodular opacities are typically seen with an interstitial process. Infiltrates may be reticular, reticulonodular, or miliary.

The usual agents producing this a pattern of pneumonia are viruses and *Mycophsma*. Viral pneumonias often have an alveolar component, , in which case they produce lobar or lobular opacities and are indistinguishable from bacterial pneumonias.

Tiny nodules, usually disseminated in both lungs, represent a miliary pattern. This pattern is typical of granulomatous pneumonias, such as Tuberculosis (figure 6) and fungal disease.

Figure 6. Miliary pattern of infiltration produced by tuberculosis.

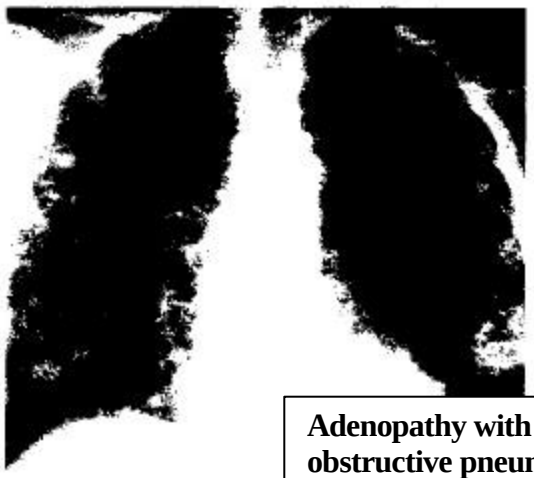

Figure 7. Pneumatoceles caused by *Pneumocystis carinii* pneumonia.

Adenopathy with peripheral infiltrates or obstructive pneumonia is a common presentation of neoplasm.

Associated findings

Recognition of abnormalities that often accompany pulmonary infiltrates *is* helpful in further limiting diagnostic possibilities.

ADENOPATHY-Pulmonary infiltrates accompanied by hilar and mediastinal adenopathy usually indicate tuberculosis or fungal disease, such as histoplasmosis. Occasionally, infectious mononucleosis and psittacosis present with adenopathy. Adenopathy with peripheral infiltrates or obstructive pneumonia is a common presentation of neoplasm. Thus, an infiltrate with adenopathy that fails to clear should prompt further investigation.

PLEURAL EFFUSION-Pulrnonary infiltrates with pleural effusion may be seen with bacterial, fungal, or viral pneumonias. The most common bacterial causes are *Staphylococcus* and gram-negative organisms.

Empyema is a pleural effusion that contains pus. The radiographic features of empyema are those of a loculated pleural effusion that fails to shift when the patient changes position. No layering of fluid occurs in the decubitus position, and fluid usually produces a prominent convex bulge that impresses the lung parenchyma.

CAVITATI0N- Most commonly associated with infections caused by gram-negative organisms or *Staphy lococcus aureus,* cavitation is also frequently seen in fungal disease (eg, coccidioidomycosis, histoplasmosis) . Tuberculosis should always be considered when cavitation is identified with an infilcrate.

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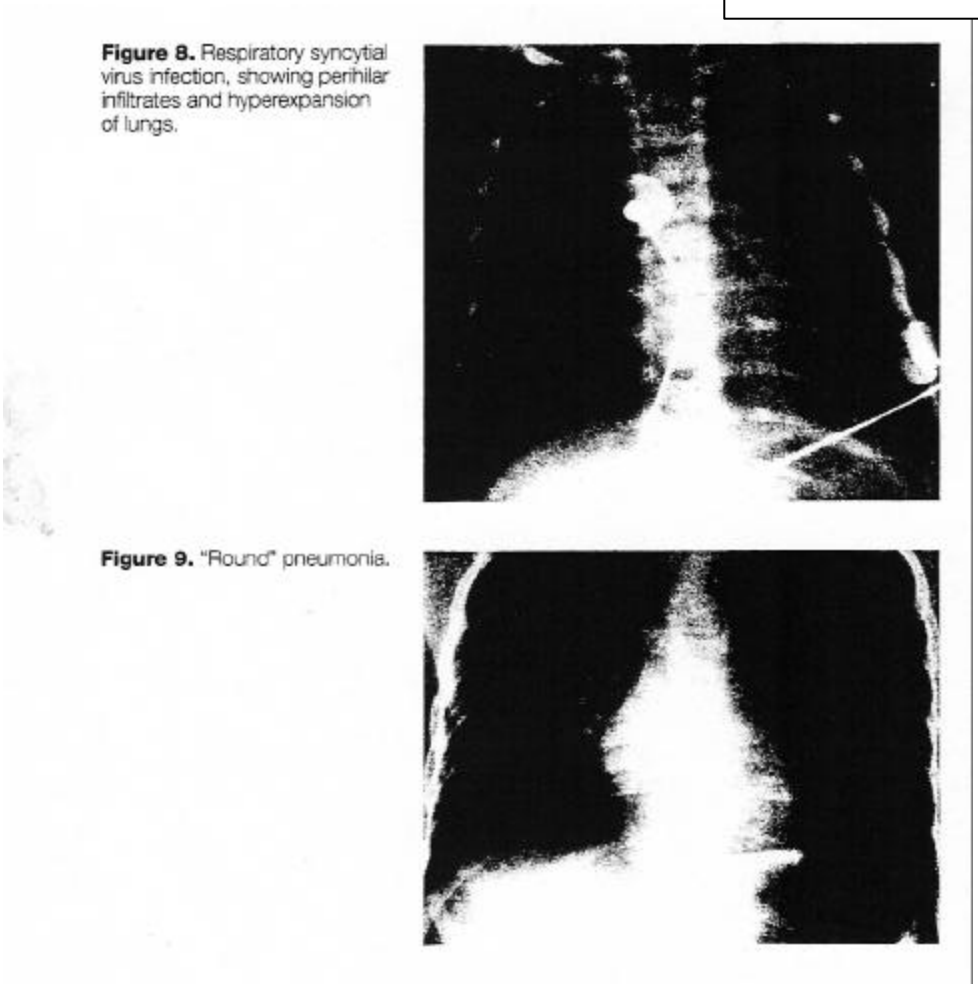

Figure 8. Respiratory syncytial virus infection, showing perihilar infiltrates and hyperexpansion of lungs.

Figure 9. "Round" pneumonia.

PNEUMATOCELES- These thin-walled cysts with little surrounding infiltrate are thought to result from an inflammatory process in distal airways that produces a check-valve obstruction. Pneumatoceles are most commonly associated with staphylococcal and hydrocarbon pneumonias and may also be seen in AIDS patients with *Pneumorystis carinii* pneumonia (figure 7). Rupture of pneumatoceles occasionally produces pneumothorax.

BRONCHOPLEURAL FISTULA- Commonly seen in gram-negative and staphylococcal infections, this finding produces a radiographic picture that resembles empyema or pleural effusion, which also contains air. The primary radiographic feature is an air-fluid level within the pleural space.

RIB INVOLVEMENT - Osteomyelitis of the ribs and associated soft-tissue abscesses may be seen along with actinomycosis, fungal disease, and tuberculosis.

Factors that influence opacification

Factors that influence the shape, appearance, distribution, and resolution of infiltrates should be considered in interpreting the radiographic picture.

PATIENT AGE- Peripheral.airways in infants and young children are , more susceptible to inflammatory narrowing than are airways in adults.Inflammatory changes ill peripheral airways result in air trapping, and hyperinflation is a common radiographic feature in children with pneumonia. A radiographic picture of bronchiolitis, consisting of perihilar infiltrates with associated hyperexpansion of the lungs, is often seen in infants and young children. Respiratory syncytial virus (figure 8) and other viral agents are the usual causative organisms.

"Round," or spherical, pneumonia (figure 9) is commonly seen in children and is usually produced by pneumococci. The round area of consolidation is nonsegmental and often simulates pulmonary or mediastinal masses.The spherical configuration is believed to be produced by centrifugal spread of the infection through the airspaces via interalveolar communications or the pores of Kohn and canals of Lambert. Round pneumonia is usually located in the posterior segments and is commonly seen in the superior segment of the lower lobes.

Although it is uncommon in adults, round pneumonia may occur, and it may be confused with neoplasm. Pneumococcus is the most common offending organism in adults as well as in children. The clinical picture should help distinguish round pneumonia from neoplasm in adult patients.

"Round" pneumonia is common in children and is usually produced by pneumococcal infection. It is uncommon in adults and may be confused with neoplasm.

OBSTRUCTION AND RESOLUTION- The majority of pneumonias resolve within 4 weeks, and all should completely clear within 8 weeks. Delayed resolution usually is due to constitutional defects in resistance rather than to a local anatomic disturbance (eg, bronchogenic carcinoma).12 Delayed resolution should prompt investigation for an underlying neoplasm.

HYDRATION- The effect of hydration on the radiographic appearance of pneumonia is controversial. Dehydration may suppress the radiographic findings of pneumonia by decreasing blood volume and hydrostatic pressure, resulting in a diminished exudative response. Caldwell and associates found no evidence in experimental work with dogs to support the effect of hydration on radiographic or histologic features of pneumonia.

DISTRIBUTION- Infiltrates may occur in a lobar, segmental, diffuse, peripheral, or central distribution in the lungs. Evaluation of distribution of infiltrates may help limit diagnostic possibilities.

Aspiration pneumonia is influenced by gravity and occurs in dependent areas. Aspiration should always be considered when basilar infiltrates are present. The right middle lobe and lingula are unusual sites for aspiration pneumonia. Most bacterial pneumonias are localized and confined to a segmental or lobar distribution. Localized consolidation may also be produced by fungal infections, such as aspergillosis.

Diffuse distribution of infiltrates (either airspace or interstitial disease) usually represents an unusual organism or an opportunistic infection. Diffuse distribution may be produced by viral agents (eg, influenza virus, herpesvirus, varicella-zoster virus, cytomegalovirus) or fungi. The miliary pattern seen with granulomatous pneumonias is almost always a diffuse process. In an immunocom- promised or AIDS patient, *P carinii* should be the primary consideration when diffuse alveolar or interstitial infiltrates are encountered.

Some pneumonias (eg, cryptococcal) have a predilection for the peripheral portions of the lungs. Pneumonias produced by hematogenous spread tend to be peripheral.

Bilateral pulmonary infiltrates, which are most pronounced in the central portion of the lungs or perihilar regions, may be produced by pneumonia but are more likely to be secondary to pulmonary edema.

Nonpneumonia causes of opacification

The primary radiographic sign of pneumonia is opacification. However, atelectasis, pleural effusion, aspiration, pulmonary embolus, pulmonary contusion, mass lesions, and pulmonary edema also present as opacification, and differentiation is very important to ensure proper treatment.

ATELECTASIS-- The important features that distinguish atelectasis from pneumonia are signs of volume loss, such as displacement of fissures, shift of mediastinal structures, elevation of the diaphragm, hyperexpansion of uninvolved lobes, approximation of the ribs, displacement of hilar structures, and absence of air bronchograms.

PLEURAL EFFUSION- Effusion produces opacities that usually obey the laws of gravity, since fluid collects in dependent areas. The superior border of an effusion typically has a meniscus configuration. Loculated fluid, such as seen in empyema, produces a bulging opacity with a convex border impressing the lung.

ASPIRATI0N- Clinical setting, distribution of the infiltrate, and onset of opacification are the keys to diagnosis of aspiration. Distribution of the infiltrate is determined by gravity, with the posterior segments of the upper and lower lobes being the most commonly involved.

The offending agent in aspiration is the low-pH gastric contents, which are an irritant and cause an outpouring of edema **fluid** into the airspaces. Airspace consolidation develops within the involved lobe, although findings on films obtained immediately after aspiration may be unremarkable. Airspace opacification becomes evident within 4 to 6 hours, followed by rapid consolidation (figures 10 and 11).

Chronic aspiration may result from esophageal abnormalities (eg, stricture, Zenker's diverticulum, achalasia). Impaired swallowing due to neuromuscular abnormalities is a common cause of aspiration. Chronic aspiration usually produces a lobular pattern with varying degrees of atelectasis and a distribution in the lungs that is determined by gravity.

PULMONARY EMBOLUS- Opacification produced by pulmonary infarction and hemorrhage, which is based on the pleura and often seen in the periphery of the lung bases, may simulate pneumonia. The configuration is usually a wedge shape with the base abutting the pleura.

The apex often has a convex, or rounded, appearance, producing the so-called Hampton hump.Pleural effusion is also commonly associated with pulmonary infarction.

PULMONARY CONTUSION- Contusion results from trauma to the thorax, with subsequent collection of edema fluid and blood within the lung parenchyma. The radiographic picture is that of airspace consolidation. Contusion may not be restricted to a lobe or segment and may occasionally develop on the side opposite the injury as a result of a contrecoup effect.

Contusion may be distinguished from pneumonia and aspiration by its rapid appearance. Airspace consolidation may be seen immediately after trauma. Opacification also clears rapidly, usually within 24 to 48 hours.

Figure 10. Aspiration pneumonia at 4 hours after aspiration.

Chronic aspiration usually produces a lobular pattern with varying degrees of atelectasis, and the distribution is determined by gravity.

Figure 11. Aspiration pneumonia at 24 hours after aspiration.

MASS LESIONS- These are usually of homogeneous density; with no air bronchograms. Round pneumonia may simulate an intrapulmonary mass. The clinical presentation and response to antibiotic therapy help distinguish round pneumonia from neoplasm.

PULMONARY EDEMA- Congestive heart failure and other disorders that produce pulmonary edema may result in diffuse alveolar infiltrates that can simulate diffuse pneumonia. Adult respiratory distress syndrome may produce a similar picture. Differentiating these disorders from pneumonia may not be possible, and diagnosis must be based on clinical presentation and physiologic information (eg, pulmonary capillary wedge pressure). Pulmonary edema is centrally located and often enlarges the heart and causes interstitial edema and pleural effusions. Nosocomial infections are frequently superimposed on pulmonary edema and adult respiratory distress syndrome. Pneumonia should be suspected if asymmetric opacification and associated findings (eg, cavitation, pleural effusion) are present.

Pneumococcus and *Haemophilus influenzae* are the most common causes of community-acquired pneumonia.

Patient and clinical information that guides diagnosis

A knowledge of clinical and epidemiologic factors is helpful in differentiating pneumonias. For example, considering the age of the patient and the clinical setting in which the infection occurs greatly improves the specificity of radiographic findings.

COMMUNITY-ACQUIRED PNEUMONIA- Causative agents of pneumonia have changed within the past few years. Pneumococcus and *Haemophilus influenzae* remain the most common causes of community-acquired pneumonia; however, agents such as *Legionella* and *Chlamydia,* which were unusual in the past, are now more frequently encountered than are aerobic gram-negative organisms and *Staphylococcus*.

Anaerobic pneumonia is often secondary to aspiration of organisms from infected teeth and gingivae, particularly in alcoholics and unconscious patients. This pneumonia has a lobular pattern and is highly necrotizing, leading to abscess formation. Common organisms responsible for anaerobic pneumonia are *Bacteroides* and *Fusobacterium*.

Smokers with chronic bronchitis are susceptible to both viral and bacterial pneumonias. *H irifluenzae* is a common cause of pneumonia in these patients.

HOSPITAL-ACQUIRED PNEUMONIA- Usually seen in debilitated patients, this disease results from alterations in host defenses. Gram- negative organisms (eg, *Klebsiella, Escherichia coli, Proteus, Pseudomonas)* are the organisms most commonly responsible. A variety of other organisms (eg, *S aureus, Serratia, Legionella)* may also produce nosocomial pneumonias and may be acquired from other patients, hospital personnel, and contaminated inhalation equipment or intravascular catheters. Hematogenous spread from other infected sires may also result in pneumonia.

In pediatric wards, respiratory syncytial virus is the most common cause of nosocomial infection, and the pattern is perihilar interstitial infiltrate with associated hyperexpansion. The lobar and lobular patterns are often seen in adults with bacterial infections.

NEWBORNS- Bacterial pneumonia is the most common type in newborns and may result from rupture of the fetal membranes, chorioarnnionitis, or aspiration of organisms during passage through the birth canal. Group B betahemolytic streptococcus is a common offending organism in this age-group.

Contamination with maternal feces at birth may produce *E coli* pneumonia. *S aureus* or gram-negative enteric bacilli may be spread by contamination on the hands of personnel in the nursery. Viral agents (eg, cytomegalovirus, rubella virus) may be transmitted through the placenta.

CHILDREN- Respiratory infection is the most common illness in older children. Lower respirarory tract infections are usually caused by respiratory syncytial virus, parainfluenza viruses, or *Mycoplasma pneumoniae*. The usual radiographic picture with these organisms is an interstitial or lobular infiltrate, and hyperexpansion is often seen. The most common bacterial pneumonia in children is pneumococcal, which presents with consolidation, often in a round configuration.

YOUNG ADULTS-- *Mycoplasma* and viruses are the most common causes of pneumonia in teenagers and young adults. The season of the year is helpful in suggesting the offending organism. Inf1uenzal infection usually occurs in early winter, adenoviral infection between January and April, and mycoplasmal pneumonia in early fall. Lobular and interstitial patterns are most often encountered in this age-group. The lobar pattern is uncommon.

OLDER ADULTS- In older adults, bacterial pneumonias are more common than are viral or mycoplasmal infections. Pneumococcus is the most common organism to affect healthy adults, and infection usually occurs in the winter months. Pneumococcal pneumorua is usually manifested by an abrupt onset of chills, fever, dyspnea, pleuritic chest pain, and productive cough.

Nosocomial infections are common in debilitated adults. These infections usually have a lobar or lobular radiographic picture.

IMMUNOCOMPROMISED HOSTS- These patients are susceptible to a variety of organisms, such as *P carinii,* cytomegalovirus, *Nocardia,* and fungi. The most common site of infection in immunocomprornised hosts is the lungs. The lobular pattern is commonly associated with bacterial or fungal infections and the interstitial or reticulonodular pattern with *P carinii* or viral infections.

Figure 12. Cavitation in anaerobic infection.

Anaerobes are the dominant organisms in aspiration pneumonia, lung abscess, and necrotizing pneumonia.

Specific Pneumonias

Individual organisms often present a typical radiographic picture that aids in their identification.

PNEUMOCOCCUS- Peumococcus (*Streptococcus pneumoniae)* is the most frequent cause of community- acquired pneumonia, found in 26% to 78% of all cases of pneumonia. The classic radiographic appearance is lobar opacification, although the absence of a lobar pattern does not exclude pneumococcal pneumonia. A lobular pattern may occur in children and is found in the majority of older hospitalized patients with complicating illness.Round pneumonia, which is common in children, is usually produced by pneumococcal infection.

STAPHYLOCOCCUS- *S* taphylococci initially affect the major and minor bronchi. They then spread to the distal airways, producing a lobular pattern. Infiltrates may coalesce to simulate a lobar pattern. The presence of cavitation, pneumatoceles, and large pleural effusions suggests staphylococcal pneumonia.

PSEUDOMONAS AERUGlNOSA- Infection with this organism most commonly presents with a patchy lobular pattern. Infiltrates may rapidly progress to extensive consolidation. Necrosis produced by *P aeruginosa* leads to multiple microabscesses, which merge to become large abscesses.

KLEBSlELLA-- This organism affects the peripheral or alveolar epithelium and may produce a pattern similar to that of pneumococcal infection with consolidation. Edema produced by *Klebsiella* results in lobar enlargement and produces a characteristic bulging of adjacent fissures. (However, bulging of fissures is not pathognomonic of *Klebsiella* and may be seen with other organisrns.)

***E* COLI-** Pneumonia secondary to *E coli* infection is usually result of bacteremia or spread from the gastrointestinal or genitourinary tract. The lobular pattern is the most common radiographic presentation. The lower lobes are more often involved, and abscess cavities and pleural effusions may be seen.

PROTEUS- This Organism may produce a lobar pattern similar to that of *Klebsiella* infection but shows a greater tendency to involve upper lobes. Cavitation may occur, but pleural effusions are less common with *Proteus* than with other gram-negative organisms.

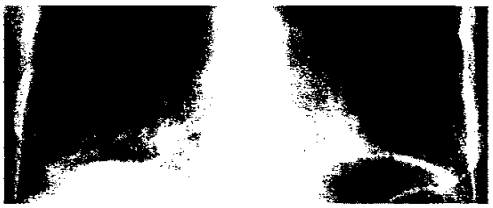

Figure 13. Mixed lobular and interstitial infiltrates in lung bases in mycoplasmal pneumonia.

Figure 14. Nodular pattern of infiltration in viral (varicella-zoster virus) pneumonia.

Actinomycosis, characterized by invasion of the chest wall and osteomyelitis of the ribs, may be caused by aspiration of organisms from infected teeth.

ANAEROBIC ORGANISMS-- Aspiration in a debilitated or unconscious patient is the usual predisposing factor for anaerobic infection (figure 12): Anaerobes are the dominate organisms in aspiration pneumonia, lung abscess, and necrotizing pneumonia.

Distribution of infiltrates is an important clue to diagnosis. It is influenced by gravity and the anatomy of the bronchial tree. The posterior segment of the right upper lobe and superior segment of the right lower lobe are the most common sites of infection. The right middle lobe and lingula are rarely involved. Recurrent opacification in the same anatomic location should also suggest anaerobic infection.

The radiographic presentation o of anaerobic infection in the lung parenchyma ranges from a lobular pattern to large abscesses. About 50% of cases result in abscess formation and pleural effusion. Empyema is a common complication.

LEGIONELIA- The source of this organism is contaminated water, such as that found in air-conditioning cooling towers. Immunocompromised and elderly patients are the most susceptible to *Legionelia* infection. The lower lobes are more commonly involved, with a lobar consolidation pattern. Pleural effusion may occur, but cavitation is unusual.

CHIAMYDIA- The radiographic presentation of chlamydia infection is highly variable. Diffuse interstitial infiltrates or a lobular or lobar pattern may be seen. Pleural effusion and adenopathy are uncommon.

ACTINOMYCES-- Aspiration of organisms from infected teeth may be the source of actinomycosis. Lobar consolidation is usually seen in the lungs; however, the characteristic features of actinomycosis are invasion of the chest wall with development of bronchopleural fistulas and osteomyelitis of the ribs.

NOCARDIA-- Infection with this organism often occurs in immunocompromjsed patients. A lobular pattern is most common. Cavitation, hilar adenopathy, and bronchopleural fistula formation are characteristic features.

MYCOPlASMA- This organism is most commonly seen in children and young adults. Up to 30% of all cases of pneumonia in the general population may be caused by *Mycoplasma*.

No radiographic pattern is pathognomonic of mycoplasmal infection.It most frequently produces a mixed pattern and may present with either segmental consolidation or a diffuse reticulonodular infilcrate. The most common presentation is an interstitial reticular pattern in the lower lobes (figure 13), which progresses to patchy airspace disease and consolidation.

Pleural effusion is uncommon but, when present, usually follows a pattern of lobar or segmental consolidation. Empyema is rare.

Figure 15. Diffuse interstitial pattern of infiltration in *Pneumocystis carinii* pneumonia.

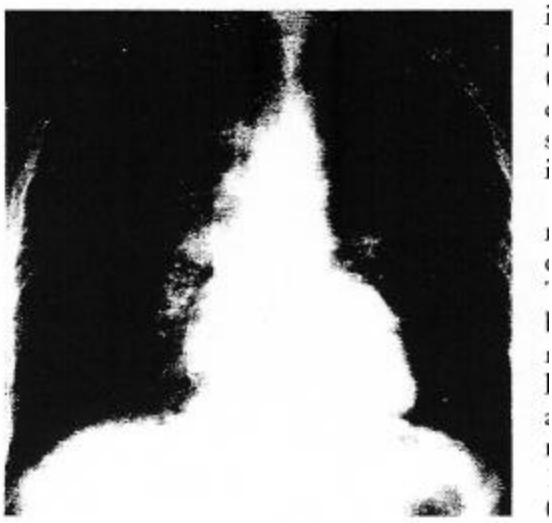

Figure 16. Diffuse mixed pattern of infiltration in *Pneumocystis carinii* pneumonia.

Radiographic differentiation of viral from bacterial pneumonia may be impossible.

VIRUSES- A multitude of viruses may cause pneumonia, the radiographic presentation of whim is variable. Some investigators have reported that bacterial and nonbacterial pneumonias cannot be distinguished with statistical reliability by means of the chest radiograph. Lobar and lobular opacification may be seen with viral as well as bacterial pneumonias, and radiographic distinction may be impossible. For example, adenovirus commonly produces a lobar or lobular pattern.

The classic radiographic pattern is diffuse interstitial infiltrates with a reticular or nodular appearance (figure 14). Conte and associates described six radiographic patterns seen in viral pneumonia, including interstitial and lobular.

P CARINII- This is the most common organism in AIDS patients, occurring in about 60% of cases. The classic radiographic picture is bilateral perihilar, basilar reticular, or reticulonodular infiltrates that rapidly progress (in 3 to 5 days) to diffuse airspace consolidation involving almost the entire lung (figures 15 and 16). Unusual radiographic findings (eg, lobar distribution, pleural effusion, sparing of damaged areas of lung) do not eliminate *P carinii* infection from consideration.

In about 10% of patients with *P carinii* pneumonia, pulmonary air-filled cysts, or pneumatoceles, develop. Rupture of these cysts may lead to spontaneous pneumothorax.

Summary

The chest radiograph can detect pneumonia, but laboratory evaluation is needed to detem1ine the specific causative organism. However, before these results become available, a presumptive diagnosis can be made with the help of chest radiography.

A lobar pattern on radiography is usually produced by pneumococcal and *Klebsiella* infections. A lobular (bronchopneumonia) pattern may be produced by *Staph lococcus,* gram-negative organisms, and anaerobes. An interstitial pattern results from viral, *Mycoplasma,* and *Pneumocystis carinii* infections. Mixed patterns may also occur.

There is great variation in dIe presentation of each infection. However, pertinent clinical information, epidemiologic factors, and associated radiographic findings (eg, adenopathy; pleural effusion, cavitation) are helpful in further limiting diagnostic possibilities.

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