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Typical Bacterial Pneumonia

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Continuing Education Activity

The severe form of acute lower respiratory tract infection that affects the pulmonary parenchyma in one or both lungs is known as pneumonia. It is a common disease and a potentially serious infectious disease with considerable morbidity and mortality. Pneumonia is the sixth leading cause of death and the only infectious disease in the top ten causes of death in the United States. Community-acquired pneumonia is diagnosed in non-hospitalized patients or a previously ambulatory patient within 48 hours after admission to the hospital. CAP is further divided into "typical" and "atypical." HAP develops more than 48 hours after hospital admission. Patients who are mechanically ventilated for more than 48 hours after endotracheal intubation can develop pneumonia known as VAP. HCAP occurs in ambulatory patients who are not hospitalized and have had extensive healthcare contact within the last 3 months. This activity reviews the evaluation and management of typical community-acquired pneumonia and highlights the role of interprofessional team members in collaborating to provide well-coordinated care and enhance patient outcomes.

Objectives:

- Explain the causes of typical community-acquired pneumonia.
- Describe the evaluation of a patient with typical community-acquired pneumonia.
- Summarize the treatment options for typical community-acquired pneumonia.
- Explore modalities to improve care coordination among interprofessional team members in order to improve outcomes for patients affected by typical community-acquired pneumonia.

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Introduction

The severe form of acute lower respiratory tract infection that affects the pulmonary parenchyma in one or both lungs is known as pneumonia. It is a common disease and a potentially serious infectious disease with considerable morbidity and mortality. Pneumonia is the sixth leading cause of death and the only infectious disease in the top ten causes of death in the United States.

Pneumonia can be classified into 2 types based on how the infection is acquired:

1. Community-acquired pneumonia (CAP): Most common type
2. Nosocomial pneumonia

- Hospital-acquired pneumonia (HAP)
- Ventilator-associated pneumonia (VAP)
- Healthcare-associated pneumonia (HCAP)

Community-acquired pneumonia is diagnosed in non-hospitalized patients or a previously ambulatory patient within 48 hours after admission to the hospital. CAP is further divided into "typical" and "atypical."

HAP develops more than 48 hours after hospital admission. Patients who are mechanically ventilated for more than 48 hours after endotracheal intubation can develop pneumonia known as VAP. HCAP occurs in ambulatory patients who are not hospitalized and have had extensive healthcare contact within the last 3 months.

Etiology

Pneumonia occurs secondary to airborne infection which includes bacteria, virus, fungi, parasites, among others.

The typical bacteria which cause pneumonia are S*treptococcus pneumoniae*, *Staphylococcus aureus*, Group A *Streptococcus*, *Klebsiella pneumoniae*, *Haemophilus influenzae*, *Moraxella catarrhali*s, anaerobes, and gram-negative organisms. These organisms can be easily cultured on standard media or seen on Gram stain, unlike atypical organisms.

Streptococcus pneumoniae is the most commonly identified bacterial cause of CAP in all age groups worldwide. Methicillin-resistant *Staphylococcus aureu*s (MRSA), Escherichia coli, and other *Enterobacteriaceae* are the predominant causes of HAP, VAP, and HCAP.

Although it is not necessary to have a predisposing condition to acquire pneumonia, having such factors makes a person more likely to develop the lung infection. Any condition or disease that impairs the host immune response, for example, older age (older than 65 years), immunosuppression, diabetes, cystic fibrosis, lung cancer, among others. Conditions which increase the risk of macro- or micro-aspiration include stroke, seizures, anesthesia, drug intoxication. Cigarette smoking, alcoholism, malnutrition, obstruction of bronchi from tumors are other common predisposing conditions.

Epidemiology

The overall rate of CAP is 5-7 per 1000 persons per year. The rate of CAP is higher in males and increases with increasing age. It is more commonly seen in winter months. The combination of Pneumonia and Influenza causes high mortality and was the eighth most common cause of death in the US and the seventh most common cause of death in Canada in 2005.

Pathophysiology

The pulmonary system and the airways are continuously exposed to particulate matter and environmental pathogens. The healthy airways normally contain some bacterial species and are not sterile. The most common mechanism through which the micro-organisms or pathogens reach the lung is known as micro-aspiration. Hematogenous spread and macro-aspiration are other mechanisms.

However, the pulmonary defense mechanisms such as cough reflex, mucociliary clearance system, immune response help maintain low levels of the microbiome. CAP occurs when there is a defect in normal host defense, or a virulent pathogen overwhelms the immune response or a large infectious microbial inoculum. The invasion and propagation of these virulent strains of bacteria in the lung parenchyma following micro-aspiration cause the host immune response to kick in leading to a cascade of inflammatory response causing pneumonia.

Alveolar macrophage is the predominant immune cell which responds to lower airway bacteria. However, a stronger immune response comes into play when an overwhelming virulent pathogen or a large inoculum causes these alveolar macrophages to recruit polymorphonuclear neutrophils(PMN) to phagocytose and engulf these bacteria. The alveolar macrophages release

cytokines namely, tumor necrosis factor-alpha and interleukins. Interleukin-8 and granulocyte colony-stimulating factor promotes neutrophil chemotaxis and maturation. The leakage of the alveolar-capillary membrane due to cytokines can lead to a decrease in compliance and hence, dyspnea. Cytokines such as IL-1 and TNF can lead to constitutional symptoms such as fever. Bacterial pneumonia is a result of this inflammatory response. These cytokines are essential for the immunity but, the excess can lead to sepsis and multiorgan failure. The body tries to balance the deleterious effects of cytokines by attenuation of several inflammatory mechanisms by IL-10.

Microbial virulence factors and predisposing host conditions make a person more vulnerable to pneumonia.[3]

Histopathology

Based on the area of the lung involved, pneumonia can be classified histologically into lobular, lobar, bronchopneumonia, and interstitial. The major types of acute bacterial pneumonia include:

- *Bronchopneumonia:* A descending infection started around bronchi and bronchioles, which then spreads locally into the lungs. Lower lobes are usually involved. Patchy areas of consolidation which represents neutrophil collection in the alveoli and bronchi.
- *Lobar pneumonia:* Acute exudative inflammation of the entire lobe. Uniform consolidation with a complete or near complete consolidation of a lobe of a lung. Majority of these cases are caused by Streptococcus pneumoniae.

Lobar pneumonia has 4 classical stages of inflammatory response if left untreated, namely:

1. Congestion/consolidation in the first 24 hours in which the lungs are heavy, red, and, boggy. Microscopically characterized by vascular engorgement and intra-alveolar edema. Many bacteria and few neutrophils are present.
2. Red hepatization/early consolidation begins 2 to 3 days after consolidation and lasts for 2 to 4 days and named because of firm liver-like consistency. The affected lung is red-pink, dry, granular and, airless. Fibrin strands replace the edema fluid of the previous phase. Microscopically marked cellular exudate of neutrophils with some showing ingested bacteria, extravasation of erythrocytes, desquamated epithelial cells, and fibrin within the alveoli are seen. The alveolar septa become less prominent because of the exudate.
3. Grey hepatization/late consolidation occurs 2 to 3 days following red hepatization and lasts for 4 to 8 days. The lung appears gray with liver-like consistency due to fibrinopurulent exudate, progressive disintegration of red blood cells, and hemosiderin. The macrophages begin to appear.
4. Resolution and restoration of the pulmonary architecture start by the eighth day. The enzymatic action begins centrally and spreads peripherally which liquefies the previous solid fibrinous content and eventually restores aeration. Macrophages are the predominant cells which contain engulfed neutrophils and debris.

Toxicokinetics

The most common cause of typical bacterial pneumonia worldwide is *Pneumococcus*. The polysaccharide capsule of *Streptococcus pneumoniae* inhibits the complement binding to the cell surface and hence, inhibits phagocytosis. Virulent pneumococcal proteins such as IgA1 protease, neuraminidase, pneumolysin, autolysin, and the surface protein A further help the organism to counteract the host immune response and allow it to cause infection in humans.

Genetic mutations causing an active efflux of drug and eventually resistance have led to an increase in drug-resistant Streptococcus Pneumoniae (DRSP) over the last few years.

Alteration in penicillin-binding protein has increased the penicillin resistance and an increased rate of penicillin-resistant *S. pneumoniae*. Penicillin resistance occurs due to failure to bind to the microbe cell wall.[1][2]

History and Physical

The signs and symptoms vary according to disease severity. The common symptoms of bacterial pneumonia include fever, cough, sputum production (may or may not be present). The color and quality of sputum provide the clue to microbiological etiology. Bacterial pneumonia mostly presents with mucopurulent sputum.

Pleuritic chest pain due to localized inflammation of pleura can be seen with any kind of pneumonia but, is more common with lobar pneumonia. Constitutional symptoms such as fatigue, headache, myalgia, and arthralgias can also be seen.

Severe pneumonia can lead to dyspnea and shortness of breath. In severe cases, confusion, sepsis, and multi-organ failure can also manifest.

Tachypnea, increased vocal fremitus, egophony (E to A changes), dullness to percussion are the major clinical signs depending on the degree of consolidation and presence/absence of pleural effusion. Chest auscultation reveals crackles, rales, bronchial breath sounds.

The respiratory rate closely correlates with the degree of oxygenation and, therefore essential in determining the severity. Hypoxia is seen in severe pneumonia, which leads to hyperventilation.

Evaluation

To start with the evaluation of any pneumonia, clinical suspicion based on careful patient history and physical exam should always be followed by chest radiography which is the most important initial test.

Chest x-ray not only shows the presence of the disease and demonstrates pulmonary infiltrate, but also provides the clue to the diagnosis whether its lobar, interstitial, unilateral or bilateral. Typical bacterial pneumonia is usually lobar pneumonia with para-pneumonic pleural effusions. However, a chest x-ray cannot reliably differentiate bacterial from a non-bacterial cause. When the labs and clinical features are positive, a positive chest radiograph is considered a gold standard for diagnosis of pneumonia. Although computed tomography (CT) is a more reliable and accurate test, its use is limited due to relatively high radiation exposure and high cost. It can sometimes be done with high clinical syndrome favoring pneumonia with a negative chest x-ray. In a hospitalized patient with high clinical suspicion and negative radiograph, empiric presumptive antibiotic treatment should be started followed by a repeat chest x-ray after 24 to 48 hours.

Complete blood count (CBC) with differentials, inflammatory biomarkers ESR and acute phase reactants are indicated to confirm the evidence of inflammation and assess severity. Leukocytosis with a leftward shift is a major blood test abnormality whereas leukopenia can occur and points towards poor prognosis.

Sputum Gram stain and culture should be done next if lobar pneumonia is suspected. The most specific diagnostic test for lobar pneumonia is sputum culture. It is very important to identify the cause for the proper treatment.

It is preferable to test for influenza during the winter months as the combination of influenza and pneumonia is fatal.

CURB-65 and pneumonia severity index help in the stratification of the patients and to determine if the patient needs hospitalization for treatment.

Routine diagnostic tests are optional for outpatients with pneumonia, but hospitalized patients should undergo sputum culture, blood culture, and/or urine antigen testing preferably before the institution of antibiotic therapy.

Thoracocentesis, bronchoscopy, pleural biopsy, or pleural fluid culture are invasive tests and are carried out very occasionally.

An open lung biopsy is the ultimate specific diagnostic test.[6]

Treatment / Management

The treatment depends on the severity of the disease. It is important to determine whether the patient needs to be treated inpatient or as an outpatient. CURB-65 pneumonia severity score or expanded CURB-65 can be used to stratify patients. One point for each factor which includes:

- Confusion
- Uremia (BUN greater than 20 mg/dL
- Respiratory rate greater than 30 per minute
- Hypotension (SBP less than 90 and DBP less than 60)
- Age older than more than 65 years

Patients with comorbid conditions such as renal disease, liver disease, cancer, chronic lung disease usually do better with inpatient treatment with IV medications.

A CURB-65 score of greater than or equal to 2 is an indication for hospitalization. A score of greater than or equal to 4 is an indication for intensive care unit (ICU) admission and more intense therapy.

Depending on the clinical response, the therapy is indicated for 5 to 7 days. A favorable clinical response is the resolution of tachypnea, tachycardia, hypotension; absence of fever for more than 48 hours. In case of delayed response, the therapy should be extended.

Empiric therapy recommended for the following:

- *Outpatient/non-hospitalized patient management:* Empiric therapy is almost always successful and usually testing is not required. In patients with no comorbidity, monotherapy with macrolides, such as azithromycin and clarithromycin are the first choice. Alternatively, newer fluoroquinolones like levofloxacin, moxifloxacin, or gemifloxacin can be used. The therapy is targeted against mycoplasma and chlamydia pneumoniae which are the common causes of less severe CAP. Patients with comorbid conditions (chronic lung or heart disease, diabetes, smoking, HIV, among others) do well with newer fluoroquinolones alone or with a combination of beta-lactam and a macrolide.
- *Inpatient non-ICU management:* The recommended therapy includes newer fluoroquinolones alone or a combination of beta-lactam/second or third-generation cephalosporin and a macrolide.
- *Inpatient ICU management:* The recommended therapy is a combination of macrolide/newer fluoroquinolone and a beta-lactam. Ampicillin-sulbactam or ertapenem can be used in patients with risk of aspiration. If there is a risk of Pseudomonas infection, a combination of anti-pseudomonal beta-lactam with anti-pseudomonal fluoroquinolone is indicated. For MRSA, vancomycin or linezolid should be added. In case of complications such as empyema, chest tube drainage is required. Surgical decortication is needed in case of multiple loculations.

All hospitalized patients who test positive for influenza virus must be treated with oseltamivir irrespective of the onset of illness.

Once the exact cause is determined, specific therapy should be initiated.[3][4][5]

Differential Diagnosis

- Asthma or reactive airway disease
- Viral Pneumonia
- Pneumonia, Fungal
- Pneumonia, Atypical bacterial
- Lung Abscess
- Bronchiectasis
- Bronchiolitis
- Asthma
- Acute and Chronic Bronchitis
- Atelectasis
- Croup
- Respiratory distress syndrome
- Aspiration of a foreign body[6][7]

Complications

- Pleural effusion
- Empyema
- Lung Abscess
- Septicemia
- Bacteremia

Enhancing Healthcare Team Outcomes

Pneumonia is a common infectious lung disease. It requires interprofessional care and the involvement of more than one subspecialty. This patient-centered approach involving a physician with a team of other health professionals, physiotherapists, respiratory therapists, nurses, pharmacists, and support groups working together for the patient plays an important role in improving the quality of care in pneumonia patients. It not only decreases the hospital admission rates but also positively affect the disease outcome. For healthy patients, the outcomes after treatment are excellent but in the elderly and those with comorbidities, the outcomes are guarded.

Review Questions

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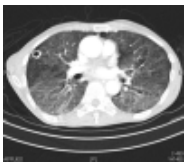
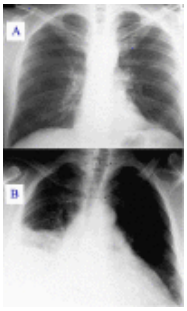
Figure



Lung Abscess, Computed Tomography Scan. The thick-walled cavitary lesion in the right lung is an abscess. Pneumonia is represented by the diffuse ground glass infiltrates seen in both lungs. Yale Rosen, Public Domain, via Wikimedia Commons (CC by 4.0). (more...)



Figure

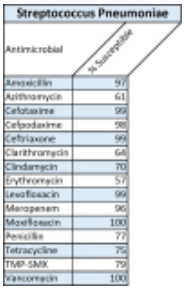
Healthy Lung and Q Fever Pneumatic Lung, Chest X-ray. X-ray A represents a normal healthy lung; X-ray B represents a lung with Q fever pneumonia. Hehkuviini, Public Domain, via Wikimedia Commons.

Figure

Lung X-ray of patient showing infection with pneumocystis carinii, Pneumonia Contributed by The National Institutes of Health (NIH)

Figure

Chest X-ray of Mycobacterium Avium-Intracellulare Pneumonia. Contributed by S Bhimji, MD



Figure

Streptococcus Pneumoniae example antibiogram Contributed by Zachary Sandman, BA

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