Pneumonia in the elderly

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Pneumonia is one of the commonest infections in elderly patients. The pathogens responsible for pneumonias in the elderly are the same as in younger adults. Because of associated cardiopulmonary disease and/or impaired host defenses, pneumonia in elderly patients is associated with increased mortality and morbidity compared to younger patients. The clinical importance of pneumonias in the elderly relates to age-dependent and pathologic changes in the immune system as well as the lungs. Pneumonias in the elderly may be classified, for clinical purposes, according to their location of acquisition, i.e. community-acquired pneumonias, nursing home-acquired pneumonias, or hospital-acquired pneumonias. The clinical presentation of pneumonias in the elderly may be difficult, due to pre-existing cardiopulmonary disease that mimics pneumonia. This review discusses the diagnostic and therapeutic approaches to elderly patients with pneumonia.

Keywords Legionnaire's disease, community-acquired pneumonia, nursing-home-acquired pneumonia, nosocomial-acquired pneumonia, antimicrobial therapy of pneumonia, antibiotic resistance

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INTRODUCTION

For centuries, pneumonia has often been the terminal infectious disease event in the elderly. Elderly patients are more predisposed to pneumonia because of their impaired gag reflex, decreased mucociliary function, waning immunity, impaired febrile response, and various degrees of cardiopulmonary dysfunction. Central nervous system disorders and/or an impaired gag reflex predispose elderly patients to aspiration pneumonia. The distribution and extent of aspirated oropharyngeal contents determine the radiologic appearance, clinical presentation and severity of the pneumonia in elderly patients. Elderly patients often have some degree of cardiopulmonary disease that has, through one or more events during their lifetime, decreased their heart and lung function. Fever resulting from pneumonia may further burden an already compromised myocardium, resulting in congestive heart failure (CHF) and/or myocardial infarction. Not uncommonly, patients presenting with CHF have pneumonia-induced fever as the proximate cause of their cardiac decompensation. Patients with long smoking histories may have bronchogenic carcinoma, which may predispose to pneumonia, depending upon extent and location. Post-obstructive pneumonias due to bronchogenic carcinomas are most common in the elderly. Patients with chronic bronchitis resulting from a lifetime of heavy smoking are also predisposed to pneumonia. Depending upon severity, chronic bronchitics have degrees of lung damage which may be further exacerbated by superimposed pneumonia. Such patients often have little normal lung reserve, and the added insult of bacterial pneumonia often presents as a severe pneumonia because of pre-existing anatomic and functional decreases in pulmonary function.

The elderly also have many underlying systemic disorders that may predispose to impaired splenic function. Humoral immunity dependent upon intact B-lymphocyte function may be decreased in the elderly. Older individuals may have a variety of systemic disorders that impair splenic function with resultant loss of antibody production. Impaired B-lymphocyte function predisposes to infection with encapsulated pathogens that are common causes of bacterial pneumonia, i.e. *Streptococcus pneumoniae* and *Haemophilus influenzae*. Infiltrative disorders of the spleen, conditions that anatomically impinge on splenic blood supply and systemic conditions associated with impaired splenic function, e.g. cirrhosis and inflammatory bowel disease, alone or in combination, may result in an age-dependent decrease in protective antibody function. Bacteria are the commonest causes of pneumonia in older individuals. The organisms affecting the elderly are the same as in young adults, but with a different age-related distribution. *Streptococcus pneumoniae* is still the most important pathogen in younger as well as older adults. However, *H. influenzae* is relatively more common in

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elderly patients than in non-elderly adults. *Moraxella catarrhalis* is of particular importance as a cause of community-acquired pneumonia (CAP) in patients with chronic bronchitis. Atypical pathogens in the elderly are the same as in younger adults but with a different age-dependent distribution. For example, *Mycoplasma* occurs in the elderly but is more common in young adults. Conversely, legionnaires' disease is more common in elderly adults than in younger adults. *Chlamydia pneumoniae* occurs in all age groups and in the nursing home setting, but probably is most common in young adults. Rickettsial and parasitic pneumonias are relatively rare in immunocompetent elderly individuals. The most important viral cause of pneumonia in the elderly is influenza, which appears in the winter months and occurs in outbreaks, either in the community or in chronic-care facilities or hospitals [1–4].

Pneumonias of the elderly may be classified according to how the infection is acquired, i.e. hematogenously or by primary inhalation. Aspiration is a variant of pneumonia acquired via inhalation. Urinary tract infections are not uncommon in elderly men and may result in urosepsis with secondary hematogenous spread to the lungs, resulting in pneumonia. Alternatively, pneumonia may be classified according to the patient's location when the pneumonia was acquired. Pneumonias acquired from the community are termed community-acquired pneumonia, those that are acquired in chronic care facilities or nursing homes are termed nursing home-acquired pneumonia (NHAP), and those that are contracted in the hospital are called hospital-acquired pneumonia (HP). HP is synonymous with nosocomial pneumonia (NP), a term which is sometimes used interchangeably with ventilator-associated pneumonia. Clearly, ventilator-associated pneumonia differs from NP or HP because the patient is intubated and on a respirator, but is otherwise equivalent. Pneumonias may also be classified on the basis of the causative organism. Since organisms pathophysiologically express themselves in a stereotypical fashion, an etiologic classification of pneumonia correlates best with the patient's signs and symptoms. Pneumococcal pneumonia, whether community acquired or nursing home acquired, presents in exactly the same fashion regardless of location, since clinical manifestations are determined by the microbe and not the location where the patient's pneumonia was acquired. Similarly, pneumococcal pneumonia may manifest itself early during hospitalisation ($\leq$hospital day 5), but does not occur later in the hospital course, i.e. after a week of hospitalisation. So-called NP due to *Streptococcus pneumoniae* presenting soon after hospitalisation, in fact, represents CAP that has become manifest in the first few days after admission to the hospital. *Streptococcus pneumoniae* pneumonia in this setting presents in precisely the same manner as hospital-acquired pneumococcal pneumonia, since it is the same clinical entity. Similarly, legionnaires' disease, whether presenting as CAP, as NHAP, or in the nosocomial setting, is accompanied by signs and symptoms referable to *Legionella*'s characteristic pattern of extrapulmonary organ involvement [1–29].

CLINICAL PRESENTATION

General concepts

Young adults with pneumonia usually present with fever, leukocytosis, and an infiltrate on the chest X-ray. Elderly patients will often have only the infiltrate, which is not always accompanied by fever or leukocytosis. For this reason, the diagnosis of pneumonia in the elderly, particularly in patients with NHAP or NP, depends heavily upon the interpretation of the chest X-ray, taking into consideration other disorders that may mimic pneumonia on the chest X-ray. Much has been written about the radiologic mimics of pneumonia, ranging from bronchogenic carcinoma, to drug reactions, to CHF. While systemic diseases with pulmonary manifestations are always in the differential diagnosis of patients with presumed pneumonia, systemic conditions are particularly likely to cause diagnostic confusion in patients with possible NHAP or NP. Most patients transferred to a hospital from a nursing home, with pulmonary infiltrates, with or without fever or leukocytosis, have, in fact, CHF. CHF may be an exacerbation of preexisting heart failure or may represent myocardial infarction and associated CHF. Interstitial lung disease, drug-induced disease, collagen vascular diseases, etc. all need to be taken into account, in addition to CHF, in the differential diagnosis of pneumonia in elderly patients.

The majority of elderly patients with pneumonias develop a productive cough. However, older patients who are dehydrated or have an impaired ability to cough may have little or no sputum production. Scant sputum suggests a viral or atypical pneumonia if all other factors are equal. Productive sputum does not differentiate an acute exacerbation of chronic bronchitis from pneumonia. The best way to differentiate tracheobronchitis or an acute exacerbation of chronic bronchitis from pneumonia is to obtain a chest X-ray. Patients with pneumonia should have infiltrates due to the pneumonia; blood-tinged sputum may occur with a variety of non-infectious diseases, e.g. pulmonary embolism/infarction, mitral stenosis, and neoplasm, but may also occur with pneumococcal or *Klebsiella* pneumonia. The sputum in legionnaires' disease may be purulent or mucoid [2,5].

Past medical history

The history, in a patient with pneumonia, provides information that may suggest the diagnosis of pneumonia or suggest alternative diagnoses for the patient's symptoms.

Questioning the patient about recent contacts with other individuals with a similar illness is particularly useful in

outbreaks of influenza or NHAP due to *C. pneumoniae*. If a patient has recently been discharged from a hospital, then readmission with pneumonia could suggest either incomplete resolution of the initial process or that the patient had developed pneumonia during the previous admission which is now manifesting as a nosocomial pneumonia. History of contact with younger individuals with respiratory illnesses may suggest mycoplasma pneumonia in the elderly. Often, *Mycoplasma pneumoniae* is not considered in the differential diagnosis, solely because of the patient's age. Elderly patients are visited by younger individuals and visit younger individuals frequently. Students may be home from school, or there may be contact with neighbors or friends with young children, and unless this avenue is explored in elderly patients with a mycoplasma-like illness, mycoplasma or *C. pneumoniae* pneumonia may be not sufficiently considered in the differential diagnosis. Similarly, contact with psittacine birds may suggest psittacosis. Elderly patients often have pets, but most pets, while capable of transmitting a variety of infectious diseases, do not usually harbor pathogens commonly associated with pneumonias. A history of strokes or dementia may predispose the patient to repeated episodes of aspiration pneumonia. Impaired gag reflex and a wide variety of esophageal disorders may also predispose the patient to repeated episodes of aspiration pneumonia, whether acquired in the community, nursing home, or hospital. Patients with pre-existing lung disease, particularly those with chronic bronchitis, are predisposed to exacerbations of chronic bronchitis as well as pneumonia. Such patients have a long previous history of heavy smoking that predisposes them to pneumonia, heart failure, and bronchogenic carcinoma. A history of recurrent pneumonia may be coincidental, or if there is a physio-anatomic reason for the repeated aspiration, e.g. central nervous system or esophageal disease, then repeated bouts of pneumonia are to be expected. Patients with systemic lupus erythematosus (SLE), those with multiple myeloma, those with chronic lymphatic leukemia (CLL), those with early HIV and alcoholics are all predisposed to contracting pneumonias caused by encapsulated organisms, e.g. *Streptococcus pneumoniae* and *H. influenzae* [30–32].

Most elderly patients who have survived into late adulthood do not have immunodeficiency problems predisposing them to contracting pneumonia. Patients with cystic fibrosis infrequently survive to old age. In contrast, those with bronchiectasis often reach the later decades of life. Patients with repeated pneumonias from the same anatomic location may have a partial endobronchial obstruction. Recurrent pneumonias in the same anatomic location should suggest an underlying bronchogenic carcinoma presenting with repeated episodes of post-obstructive pneumonia that do not fully clear, or that recur frequently in the same location [1–3].

It is as important to obtain a pertinent medical history of cardiac and lung conditions that may mimic pneumonia as it is to ascertain the factors that predispose to pneumonia in the elderly. Particularly important in the elderly is a history of interstitial lung disease, regardless of etiology. Comparing previous films with current chest films will usually clarify the etiology of the pulmonary infiltrates. A history of collagen vascular diseases, e.g. rheumatoid arthritis or SLE, may explain infiltrates and/or pleural effusions seen on the chest X-ray. A previous history of radiation to the mediastinum may suggest radiation pneumonitis as the cause of an abnormal chest film. A detailed medication history is useful, as it may reveal drugs that may cause pulmonary fibrosis, pleural effusions, pulmonary infiltrates, interstitial lung disease and non-cardiac pulmonary edema. A cardiac history is as important as a pulmonary history, because of the frequency of CHF in elderly patients. Patients may have an exacerbation of pre-existing heart failure, or may have heart failure due to an acute coronary event. Worsening of pre-existing CHF may occur with coronary or valvular heart disease. In addition to the history, the chest X-ray should reveal cardiomegaly, with or without pleural effusion, and there should be signs of CHF present on the physical examination. CHF is the diagnosis most likely to mimic pneumonia in elderly patients. The history should look for factors predisposing to pulmonary embolus or infarction, which may also mimic pneumonia in elderly patients. A careful history may reveal prolonged stasis secondary to confinement or prolonged travel. Malignancies associated with a hypercoagulable state may also predispose the patient to pulmonary emboli. Other systemic diseases may also directly or indirectly affect the lungs. Scleroderma may decrease esophageal motility predisposing to aspiration pneumonia, and cause interstitial lung disease mimicking pneumonia. A history should prompt questions relevant to disorders that predispose to pneumonia [30–33].

Physical examination

Physical examination of the chest reveals adventitious sounds over the area of pneumonia. Loud, tubular breath sounds suggest copious secretions in the large bronchi, and are not diagnostic of pneumonia *per se*, but may accompany pneumonia. Dullness at the bases may be reflective of carcinoma, CHF, pleural effusion due to carcinoma or an intra-abdominal process, or a bacterial pneumonia. Bilateral pleural effusions are rarely, if ever, due to an infectious etiology. Bilateral pleural effusions should suggest CHF as the most likely diagnostic possibility. Legionnaires' disease may also present with a unilateral pleural effusion. Among the bacterial pneumonias, most frequently *H. influenzae* presents with a mild to moderate pleural effusion. Pneumococcal pneumonia and klebsiella pneumonia more often present with empyema rather than pleural effusion, but the clinical presentation, in terms of auscultation of the chest, would be the same. Dullness may also be reflective of consolidation over the involved lobe of the

lung. Consolidative pneumonias may occur with any of the pathogens and are not specific for any particular etiologic agent [1,2,8,12,19,27–29].

The physical findings associated with influenza are minimal. Because influenza is an interstitial process, the auscultation of the chest is silent in primary influenza pneumonia. If rales are heard, especially if they are localised to one segment or lobe in a patient with viral pneumonia, then there is a superimposed bacterial pneumonia also present. In mycoplasma pneumonia, there is a discrepancy between the clinical findings, e.g. auscultatory findings, and the appearance on chest X-ray, which may be a clue to the diagnosis. *C. pneumoniae* pneumonia has no pathognomonic findings on physical examination, and resembles mycoplasma pneumonia closely in clinical presentation, except for the added presence of laryngitis. Laryngitis may be caused by one of many respiratory viruses, but these viruses do not usually cause viral pneumonia in elderly adults. The association of pneumonia and laryngitis should suggest *C. pneumoniae* pneumonia until proven otherwise, since hoarseness is a feature with *C. pneumoniae* pneumonia but not *M. pneumoniae* pneumonia [1–4].

Laboratory tests

As previously mentioned, the chest X-ray is essential to rule out conditions that may mimic pneumonia and confirm the presence of pneumonia. Other findings on the chest X-ray may have important diagnostic significance, e.g. the anatomic distribution of the lesion, the appearance of the lesion, whether the process is alveolar or interstitial, whether the process is confined to perihilar or peripheral regions, or whether the infiltrates are confined to segments or lobes or ignore the anatomic segments of the lungs. All elderly patients with pneumonias should have blood cultures and a full blood count in addition to the chest X-ray. Other tests should be ordered as suggested by elements of the history, physical examination or chest X-ray [5,6].

If an atypical pneumonia is suspected, then serum glutamic-oxaloacetic transaminase, serum glutamate pyruvate transaminase, alkaline phosphatase and serum phosphorus should be obtained. Patients with productive cough should have a Gram stain and culture of expectorated sputum. Patients with chronic bronchitis need not have their sputum Gram stained or cultured, since results invariably show normal flora or mixed flora, which is unhelpful in establishing a specific etiologic diagnosis. For specific pathogens, acute and convalescent titers should be requested, depending upon the pattern of organ distribution and the presence or absence of relative bradycardia. Specific serological investigations may be requested for *Legionella*, *Mycoplasma pneumoniae*, or *C. pneumoniae*. Separate IgM and IgG titers, not simply a chlamydia titer, should be requested. If *Mycoplasma* is suspected, then cold agglutinin titers may be ordered, which are most likely to be elevated early in the course of the illness. A cold agglutinin titer of $\geq$64 is most likely due to mycoplasma cold agglutinins rather than to viruses or other systemic disorders associated with elevations of cold agglutinins. Specific *C. pneumoniae* IgM and IgG titers should be ordered. If chlamydia titers are requested, the laboratory may respond with a combined IgM/IgG result, which is unhelpful, or with a *C. trachomatis* titer. If there is psittacine bird contact, then acute and convalescent titers for *C. psittaci* may be obtained. Convalescent titers should preferably be obtained 6–8 weeks after the acute titers. Clinicians should remember that all patients do not mount an antibody response, and antimicrobial therapy may blunt or delay convalescent titers. Increases in the serum transaminases may suggest legionnaires' disease, or alternatively CHF due to passive congestion of the liver, or infiltrate of liver disease, which may also be affecting the lungs. Microscopic hematuria in elderly men should suggest benign prostatic hypertrophy (BPH), but if otherwise unexplained in the patient with pneumonia, should suggest legionnaires' disease. Legionnaires' disease may also be diagnosed by direct fluorescent antibody (DFA) staining of the sputum, which has a relatively low yield, but provides immediate confirmation of the diagnosis when positive. DFA positivity for *Legionella* in the sputum decreases rapidly after the initiation of appropriate antimicrobial therapy. Therefore, DFA should be obtained from patients suspected of having legionnaires' disease with purulent sputum, as soon as possible after admission, and preferably before antimicrobial therapy is initiated. In patients where *Legionella* is suspected, the legionella urinary antigen test may be of use. Legionella antigenuria may take a week or two to become positive, but persists for many months even after resolution of legionella pneumonia. Legionella antigenuria is most helpful as a retrospective confirmatory test, but has limited usefulness early on in the illness. The other limitation of the legionella antigen test is that it is positive only for *L. pneumophila* serogroup 1 and is not positive for other *L. pneumophila* serogroups or the many non-*L. pneumophila* species that cause legionnaires' disease. The clinician should order other tests that will be helpful in ruling out non-infectious disorders mimicking pneumonias as suggested by the history and physical examination [5–7].

Serial chest X-rays are important in evaluating the efficacy of the patient's therapy or lack of response, which may indicate inappropriate antimicrobial therapy or a non-infectious disease mimic of pneumonia. After the initial chest X-ray, a repeat chest X-ray 3–5 days after the initiation of appropriate antimicrobial therapy is most helpful. If the patient has begun to improve, repeat chest X-rays are usually not necessary unless the patient fails to resolve completely, or the pneumonia worsens or recurs. Abnormalities on the chest X-ray may persist, particularly with pneumococcal pneumonia, for months after clinical defervescence. Repeated chest X-rays are not necessary as long as the

patient has clinically defervesced and a second film has shown interval improvement.

If influenza is suspected, the virus may be cultured from the nose or oropharyngeal secretions, or diagnosed by serologic means. Outbreaks of *C. pneumoniae* pneumonia in nursing homes are best diagnosed serologically using specific IgM and IgG *C. pneumoniae* titers obtained acutely and during the convalescent period [1–4].

ANTIMICROBIAL THERAPY

General considerations

The selection of empirical antimicrobial therapy for pneumonia acquired in the community, nursing home or hospital depends on adequate coverage of the presumed pathogens. However, before antimicrobial therapy is selected, other considerations need to be taken into account. Patients should be questioned regarding drug allergies, particularly reactions to penicillin and sulfonamides. Patients with a history of penicillin allergy should be questioned as to the nature of the allergy, to determine if it was an anaphylactoid or non-anaphylactoid reaction. Patients who give a vague history of penicillin allergy, or who manifest their allergy with fever or a maculopapular rash, may be given β-lactam antibiotics. Those with anaphylactoid reactions should not be treated with β-lactam antibiotics but may be treated with doxycycline, fluoroquinolones, monobactams, or carbapenems. Except for trimethoprim–sulfamethoxazole, none of the other commonly used antibiotics for pneumonias contain sulphonamide moieties.

Elderly patients often have various degrees of liver and hepatic function, which are important in antibiotic selection and dosing. Patients with advanced liver disease may need to have antibiotics that are hepatically eliminated and inactivated decreased in terms of daily dose. Alternatively, the pneumonia may be treated with antibiotics that are eliminated or inactivated primarily via the renal route. Since there are no good tests of liver function, as exist for renal function, the clinician must make a clinical judgment in decreasing the dose of hepatically eliminated antimicrobials. Mild to moderate hepatic insufficiency can usually be treated safely with drugs that are primarily hepatically eliminated or inactivated [34,35].

If the antibiotic selected to treat an elderly patient with pneumonia is eliminated primarily via the renal route, then the daily dose should be decreased in proportion to the decrease in renal function. Since the creatinine in elderly patients may not reflect renal function, the dosage adjustments of renally eliminated antibiotics should be based on measurements or estimates of the creatinine clearance. If a patient's creatinine clearance is half that of normal individuals, then the daily dose should be decreased by about half. Dosing adjustments may be achieved by either decreasing the dose and maintaining the dosing interval, or by maintaining the dose and increasing the dosing interval, or by decreasing the dose and increasing the dosing interval such that the daily dose is decreased proportionately to the creatinine clearance. In patients with severe renal insufficiency approaching anuria, dose adjustments may be made on the basis of the creatinine clearance, or alternatively, an antibiotic of the appropriate spectrum which is primarily hepatically eliminated or inactivated may be used instead. In treating patients on dialysis, it is important to note whether the patient is on chronic ambulatory peritoneal dialysis or hemodialysis, since antibiotics are not removed equally in each type of dialysis process. Many clinicians prefer to use antibiotics that are not removed by dialysis, thus eliminating the need for complex calculations. Clinicians should consult standard references on dosing antimicrobials in dialysis, or obtain an infectious disease or renal consultation to assist them with guidance in dosing specific drugs in patients using peritoneal dialysis or hemodialysis [33,34].

Elderly patients often have poor venous access, making intravenous therapy, particularly in nursing home patients, difficult. Patients admitted to the hospital with CAP, or developing pneumonia within the hospital, can be treated intravenously, since venous access can usually be obtained by central line or by cut down, if necessary. In the past, the intramuscular route of administration has been relied upon, particularly in chronic-care facilities, where lack of intravenous teams and the difficulties of placing intravenous lines in elderly patients are problems. Except for aminoglycosides and ceftriaxone, most antibiotics used for pneumonias should not be administered intramuscularly. Since elderly patients often have very decreased muscle mass, it is difficult and uncomfortable for patients to receive antimicrobial therapy via this route [5,30,34].

Because of the difficulties with intravenous and intramuscular administration of antimicrobials, there has been an increasing reliance recently on treating patients with pneumonias totally or partially with oral antibiotics. Patients with nosocomial pneumonias continue to be treated for most, if not all, of their course with intravenous antibiotics. In contrast, patients with CAP who are admitted to the hospital are usually started on empirical antimicrobial therapy with an intravenously administered antibiotic, and patients who defervesce after 48 h are switched to an equivalent oral antibiotic.

There has been a great increase in the introduction of intravenous to oral switch programs in hospitals to treat pneumonias as well as other infectious diseases. Intravenous to oral switch programs have important pharmacoeconomic advantages for the healthcare system, and important advantages for the patient in the hospital. Oral antimicrobial therapy eliminates the need for venous access and may permit earlier patient discharge from the hospital. By decreasing or eliminating intravenous antibiotics, the frequency of phlebitis associated with intravenous therapy is all but eliminated. The

Table 1 Causes of pneumonia in the elderly

	Episodic	Pathogens (certain groups)	Outbreaks
Community-acquired pneumonia (CAP)			Viral influenza
Typical (85%)	*Streptococcus pneumoniae* *Haemophilus influenzae* *Moraxella catarrhalis* Oral anaerobes	*Klebsiella pneumoniae* (chronic alcoholics)	
Atypical (15%)	*Legionella* *Mycoplasma* *Chlamydia pneumoniae*	*Staphylococcus aureus* (only postviral influenza, otherwise not a case of CAP)	
Nursing home-acquired pneumonia (NHAP)	*Streptococcus pneumoniae* *Haemophilus influenzae* *Moraxella catarrhalis* *Legionella* Oral anaerobes	Oral anaerobes (aspiration pneumonias)	Influenza *Chlamydia pneumoniae*
Nosocomial pneumonia (NP) NP is not usually due to *Staphylococcus aureus* (MSSA/MRSA), enterococci (*Enterococcus faecalis, Enterococcus faecium*), *Stenotrophomonas maltophilia, Burkholderia cepacia, Citrobacter,* or *Enterobacter*	*Pseudomonas aeruginosa* Aerobic gram-negative organisms		*Acinetobacter* *Legionella*

MSSA, methicillin-susceptible *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*.

pharmacokinetic advantages of earlier discharge of patients recovering from pneumonia with oral antimicrobial therapy should not be underestimated, as the savings are profound. Oral antimicrobial therapy is not only important in the treatment of hospitalised patients with CAP but is particularly important for patients with pneumonia in chronic care facilities. NHAP patients are the group that benefits most from oral antimicrobial therapy. The personnel in nursing homes are not as readily available as personnel in the hospital setting. The main patient population is elderly and has limited muscle mass and poor venous access. Treating NHAP completely by the oral route has several advantages for the patient. Early oral antibiotic treatment of a NHAP may permit the patient to remain in the nursing home and complete the course of therapy there. Early treatment of NHAP may prevent the patient from having to be transferred to a tertiary-care facility for hospitalisation, which may be unnecessary if oral antimicrobial therapy is initiated in the chronic-care facility [30–36](Table 1).

Selection of empirical antibiotic therapy

Empirical antimicrobial therapy should be based on the presumed pathogens, which differ according to the site of acquisition of the patient's pneumonia. Clinicians should be familiar with the most likely pathogens to be encountered in patients with CAP, NHAP, or NP, in order to select an antimicrobial with the appropriate spectrum. Optimal antimicrobial therapy neither misses important pathogens nor provides excessive coverage of known or non-existent pathogens [37,38].

The pathogens responsible for CAP are *Streptococcus pneumoniae*, *H. influenzae*, and *Moraxella catarrhalis*. *K. pneumoniae* is an additional consideration in those with alcoholic cirrhosis. *Enterobacter*, *Serratia*, *Acinetobacter* and *Pseudomonas aeruginosa* need not be included in empirical coverage for elderly patients with CAP. Community-acquired aspiration pneumonia is due to the aspirated anaerobic oropharyngeal flora. The anaerobes above the waist, including those of the oropharyngeal flora, do not require anti-*Bacillus fragilis* coverage, and are usually sensitive to most antibiotics selected for treating pneumonias. While aspiration pneumonia is an important clinical entity, with its attendant mortality and morbidity, it is not an important therapeutic consideration. Approximately 85% of CAPs are due to the typical bacterial pathogens cited above and, depending upon geographic region, the remaining 15% may be caused by the atypical pathogens, e.g. *Legionella*, *Mycoplasma*, or *C. pneumoniae*. *Legionella* and *C. pneumoniae* are the most common causes of atypical pneumonias in the elderly, and *Mycoplasma pneumoniae* is relatively less common in this age group [6]. Most clinicians prefer to cover both typical and atypical pathogens with an empirical antimicrobial antibiotic. Since most elderly patients are taking multiple medications, polypharmacy is a potential problem in terms of drug–drug interactions [3,6,34,37–39].

Since combination therapy is not better than monotherapy, monotherapy is preferred on the basis of lower cost and simplicity. Combination therapies that have been used to treat CAP include a third-generation cephalosporin, usually ceftriaxone, plus doxycycline or a macrolide. In parenteral regimens, erythromycin or azithromycin have been used most frequently in combination with ceftriaxone. Ceftriaxone, doxycycline or a respiratory quinolone are popular monotherapy regimens. Ceftriaxone used alone is effective against all of the typical pathogens, but misses the atypical pathogens. Ceftriaxone has no oral equivalent limiting its application to intravenous to oral switch programs. Macrolides should not be used as monotherapy in treating CAP, because approximately 20% of strains of *Streptococcus pneumoniae* are resistant to all macrolides. Doxycycline is available intravenously and orally, and is effective against both typical and atypical pathogens. Both ceftriaxone and doxycycline are effective against most strains of penicillin-resistant *Streptococcus pneumoniae*. The respiratory quinolones are quinolones that are highly active against both the typical and atypical respiratory pathogens causing CAP. Because ciprofloxacin is relatively inactive against *Streptococcus pneumoniae*, even though it is active against the atypical pathogens, it is not termed a 'respiratory quinolone'. Levofloxacin is the first of the respiratory quinolones and the one that has been used most extensively. At the present time, other respiratory quinolones, e.g. gatifloxacin, are equivalent to levofloxacin in their activity against both typical and atypical pathogens, as well as most strains of penicillin-resistant pneumococci. Respiratory quinolones are ideal in intravenous to oral switch programs. Because their bioavailability is so high, e.g. 99–100% for levofloxacin, these antibiotics are ideal not only for intravenous to oral switch programs, but also in the treatment of CAP and NHAP when used as sole agents orally [36–39].

Since the pathogen distribution of NHAP most closely resembles CAP, NHAP should be treated in the same way as CAP. Empirical coverage in NHAP should be directed against *Streptococcus pneumoniae*, *H. influenzae*, or *Moraxella catarrhalis*. As with CAP, aspiration pneumonia, a common cause of NHAP, may be treated with any of the monotherapy or combination therapy regimens mentioned above. Because oral monotherapy has advantages in HP, doxycycline or a respiratory quinolone are ideal agents for the treatment of NHAP. The inability to achieve intravenous access, or delays in achieving access, frequently result in the transfer of patients with NHAP to hospitals for the treatment of their pneumonias. The early administration of appropriate oral antibiotics in NHAP has the advantage of treating the pneumonia as early as possible, and may remove the need to transfer the patient to a tertiary-care facility [10–12].

Nosocomial pneumonias are caused by aerobic Gram-negative bacilli found in the hospital environment. Coverage is usually directed against *P. aeruginosa*, because it is the most invasive organism causing pneumonia in the hospital setting. Necrotising pneumonia due to *P. aeruginosa* is not common but is associated with high mortality and morbidity. Antibiotics that are effective against *P. aeruginosa* are usually effective against the other aerobic Gram-negative bacilli that may cause HPs, e.g. *Escherichia coli*, *K. pneumoniae*, or *Serratia marcescens.* Appropriate empirical therapy may be accomplished in several ways, depending upon the presence or absence of *P. aeruginosa* as a likely pathogen. If the patient presents with a necrotising pneumonia characterised by rapid cavitation in the chest X-ray and a fulminant clinical course, then most clinicians prefer double antipseudomonal drug coverage. Other popular regimens include an empirical double-drug antipseudomonal for the usual 14-day course of therapy, regardless of the etiology of the NP. Alternatively, some centers prefer to initiate therapy with double antipseudomonal drug coverage and discontinue one antibiotic after 72 h, if *Pseudomonas* is not apparent clinically or isolated from the blood. Another approach has been to initiate therapy with a single antipseudomonal antibiotic, and add a second antipseudomonal antibiotic if *Pseudomonas* becomes clinically apparent or is grown from the bloodstream after 72 h. Fourteen days is the usual duration of therapy, regardless of the regimen selected [15,18,40,41].

Nosocomial aspiration pneumonia is due to aspirated oropharyngeal secretions that have been colonised by aerobic Gram-negative bacilli during the first week of the hospital stay. These aspirated oropharyngeal contents contain anaerobic organisms, as in the case of community-acquired aspiration pneumonia, but, in addition, contain aerobic Gram-negative bacilli from the hospital environment. Since anaerobic organisms are not an important therapeutic consideration in aspiration pneumonia, the therapy of nosocomial pneumonia, whether due to aspiration or not, should be directed against aerobic Gram-negative bacilli and not anaerobic organisms, just as in CAP or NHAP aspiration pneumonia [16,23].

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