SPECIAL SECTION: AGING AND INFECTIOUS DISEASES

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# Community-Acquired Pneumonia in the Elderly

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**Pneumonia in the elderly is a common and serious problem with a clinical presentation that can differ from that in younger patients. Older patients with pneumonia complain of significantly fewer symptoms than do younger patients, and delirium commonly occurs. Indeed, delirium may be the only manifestation of pneumonia in this group of patients. Alcoholism, asthma, immunosuppression, and age >70 years are risk factors for community-acquired pneumonia in the elderly. Among nursing home residents, the following are risk factors for pneumonia: advanced age, male sex, difficulty in swallowing, inability to take oral medications, profound disability, bedridden state, and urinary incontinence. *Streptococcus pneumoniae* is the most common cause of pneumonia among the elderly. Aspiration pneumonia is underdiagnosed in this group of patients, and tuberculosis always should be considered. In this population an etiologic diagnosis is rarely available when antimicrobial therapy must be instituted. Use of the guidelines for treatment of pneumonia issued by the Infectious Diseases Society of America, with modification for treatment in the nursing home setting, is recommended.**

Managing pneumonia in an elderly patient requires an appreciation of many aspects of geriatric medicine, including the demographics of our aging population [1, 2], the effect of pneumonia on the general health of an elderly person, and knowledge of how pneumonia in this population is different than in younger populations. As stated by Sir William Osler [3], "in old age, pneumonia may be latent, coming on without chill, the cough and expectoration are slight, the physical signs ill-defined and changeable, and the constitutional symptoms out of all proportion."

Most patients who require hospitalization for the treatment of community-acquired pneumonia (CAP) are elderly, and most are treated by nonspecialists. In a retrospective study of 13,919 outpatients and inpatients ⩾65 years of age with pneumonia (nursing home residents excluded), Dean et al. [4] found that a pulmonary specialist was involved in providing care in 10.6% of the episodes, an infectious disease specialist in 0.9%, and both in 0.2%. Involvement of a specialist was more likely for cases of pneumonia that required hospitalization for treatment than for cases that did not require it (20% vs. 8.6%) and more likely for episodes resulting in death than other episodes (20.5% vs. 11.2%) [4].

Niederman et al. [5] calculated the annual cost of treating patients aged ⩾65 years with pneumonia to be $4.8 billion, compared with $3.6 billion for those aged <65 years with pneumonia. They also noted that the average hospital stay for an elderly person with pneumonia was 7.8 days, at a cost of $7166, whereas for a younger patient the corresponding values were 5.8 days and $6042.

## Pneumonia in the Elderly

*Definition.* Pneumonia is an infection involving the alveoli and bronchioles. It may be caused by bacteria, viruses, or parasites. Clinically pneumonia is characterized by a variety of symptoms and signs. Cough (which may be productive of purulent, mucopurulent, or "rust-colored" sputum), fever, chills, and pleuritic chest pain are among its manifestations. Extrapulmonary symptoms such as nausea, vomiting, or diarrhea may occur. There is a spectrum of physical findings, the most common of which is crackles or rales in the lungs. Other findings in the lungs may include dullness to percussion, increased tactile and vocal fremitus, bronchial breathing, and a pleural friction rub.

It is important to remember that pneumonia in the elderly may present with few respiratory symptoms and signs (data given below) and instead may be manifest as delirium, wors-

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ening of chronic confusion, and falls. Delirium or acute confusion was found in 45 [44.5%] of 101 elderly patients with pneumonia studied by Riqueleme et al. [6], compared with 29 (28.7%) of 101 age- and sex-matched control subjects. Falls are usually an indication that the person is ill. Among the healthy elderly, rough or slippery ground accounted for 54% of falls, but in the sick elderly this factor accounted for only 14% of falls [7]. Dizziness, syncope, cardiac and neurological disease, poor health status, and functional disability are more likely to account for falls among the sick elderly [7].

*Epidemiology.* Pneumonia is a common and often serious illness. It is the sixth leading cause of death in the United States. About 600,000 persons with pneumonia are hospitalized each year, and there are 64 million days of restricted activity due to this illness [8, 9]. The caregiver burden associated with pneumonia has not been measured, although we know that long-term caregiving is associated with an increased mortality rate among the caregivers [10]. The mortality rate among persons providing long-term care and experiencing strain has been reported to be 63% higher than among noncaregiving control subjects [10].

Recovery is prolonged in the elderly, especially the frail elderly who may require up to several months to return to their baseline state of mobility. Indeed, hospitalization, with its enforced immobility, often hastens functional decline in the elderly; 25%–60% of older patients experience a loss of independent physical function while being treated in the hospital [11]. Twenty-one percent of those aged >85 years need help with bathing and 10% need help in using the toilet and transferring [11]. The presence of any or all of the following identifies elderly persons at greatest risk for functional decline: decubitus ulcer, cognitive impairment, functional impairment, and low level of social activity [12].

Older patients with pneumonia complain of fewer symptoms than do younger patients with pneumonia; patients aged 45–64, 65–74, and ⩾75 years had 1.4, 2.9, and 3.3 fewer symptoms than patients aged 18–44 [13].

The incidence of pneumonia is highest at the extremes of age. Jokinen et al. [14] studied all patients with suspected or confirmed pneumonia among 46,979 inhabitants of 4 municipalities in the province of Kuopio, Finland, from 1 September 1981 through 31 August 1982. The age-specific incidences per 1000 inhabitants were 36.0 for those aged <5 years; 16.2 for those aged 5–14 years; 6.0 for those aged 15–59 years; 15.4 for those aged 60–74 years; and 34.2 for those aged ⩾75 years. Forty-two percent were admitted to the hospital, and the case-fatality rate was 4%. In another population-based study in a Finnish town, Koivula et al. [15] found that each year 14 per 1000 persons ⩾60 years of age developed pneumonia. Seventy-five percent of these cases were CAP.

It is interesting to examine the mean age of patients who require hospitalization for treatment of CAP over the past several decades. From October 1969 through March 1970, Dorff et al. [16] studied 148 consecutive patients with pneumonia who were admitted to the Milwaukee County General Hospital (Milwaukee, Wisconsin) and found that "patients tended to be elderly" (mean age, 55 years). Sullivan et al. [17] noted that the mean age of 292 patients with CAP admitted to Grady Memorial Hospital in Atlanta from 1 July 1967 through 30 June 1968 was 54 years. In contrast, a study in Halifax, Nova Scotia, conducted from November 1981 to 15 March 1987 showed that the mean age of the 719 patients with CAP was 63.2 years [18]. A chart review of all patients with CAP admitted to 20 Canadian hospitals (11 teaching and 9 nonteaching facilities) during the months of November 1996, January 1997, and March 1997 showed that the mean age ± SD of the 858 patients was 69.4 ± 18 years [19].

Meehan et al. [20] focused on 14,069 Medicare patients aged ⩾65 years who required hospitalization for CAP. They noted that 30.3% were aged 64–74 years, 41.8% were aged 75–84 years, and 27.8% were aged ⩾85 years. Patients with CAP who are treated on an ambulatory basis are much younger than those who are treated in the hospital. Only 18.4% of 944 patients treated for pneumonia on an ambulatory basis were aged ⩾65 years, whereas 58.7% of the 1343 patients who required admission to the hospital for the treatment of pneumonia were in this age group [21]. From these observations, there is little doubt that most patients who are hospitalized with CAP are elderly.

The attack rate for pneumonia is highest among those in nursing homes. Marrie et al. found that 33 of 1000 nursing home residents per year required hospitalization for treatment of pneumonia, compared with 1.14 of 1000 adults living in the community [22]. Loeb et al. [23] studied 475 residents of 5 nursing homes and noted that there were 1.2 episodes of pneumonia per 1000 resident-days. In another study the incidence of pneumonia among residents of long-term care facilities was 0.27 to 2.5 episodes per 1000 patient-days [24]. Pneumonia is the leading cause of infection requiring transfer of nursing home patients to the hospital, accounting for 10%–18% of all admissions for CAP [24].

*Risk factors and predictors of outcome.* The risk factors for CAP in the elderly and for nursing home–acquired pneumonia are given in tables 1 and 2. Table 3 gives factors that indicate a poor prognosis in this group of patients [26].

Torres et al. [27], in a study of 124 patients with chronic obstructive pulmonary disease and CAP (mean age ± SD, 67 ± 11 years; 115 males; 2 patients at a nursing home) found that the overall mortality rate was 8%; for the 30 (24%) who required treatment in the intensive care unit, it was 17%.

Risk factors for specific etiologies of pneumonia may differ from those for pneumonia as a whole. Thus, dementia, seizures, congestive heart failure, cerebrovascular disease, and chronic obstructive lung disease were particular risk factors for pneumococcal pneumonia [28]. In a population-based case-control study, Nuorti et al. [29] found that cigarette smoking was the

**Table 1.** Risk factors for community-acquired pneumonia (CAP) in the elderly.

| Type of study, reference; risk factor (RR) |
|---|
| Community-based [15] |
| Alcoholism (9) |
| Asthma (4.2) |
| Immunosuppression (1.9) |
| Age >70 vs. 60–69 y (1.5) |
| Case-control [25][a] |
| Suspected aspiration |
| Low serum albumin level |
| Swallowing disorder |
| Poor quality of life |

[a] Elderly patients who required admission to hospital for CAP, matched for age and sex.

strongest independent risk factor for invasive pneumococcal disease among nonelderly immunocompetent adults. It is likely that this is also true for elderly adults. Among HIV-infected patients, the rate of pneumococcal pneumonia is 41.8 times higher than for those in the same age group who are not HIV-infected [30]. Risk factors for legionnaires disease include male sex, tobacco smoking, diabetes, hematologic malignancy, cancer, end-stage renal disease, and HIV infection [31].

There is a high incidence of silent aspiration in elderly patients with CAP [32]. Kikuchi et al. [32] examined the role of silent aspiration during sleep in 14 elderly patients with CAP and 10 age-matched control subjects by applying a paste containing indium-111 wrapped in gauze and fixed to the teeth. Scanning of the thorax demonstrated that 71% of the study patients aspirated, compared with 10% of the control subjects ($P < .02$). Just over 28% of patients with Alzheimer's disease [33] and 51% of those who had had a stroke [34] aspirated, according to videofluoroscopy. Croghan et al. [35] found that placement of a feeding tube in patients who had aspirated, as revealed by videofluoroscopy, was associated with a higher rate of pneumonia and death than for those who aspirated but didn't receive such a tube.

Host factors that also have had a major impact on the epidemiology of pneumonia are an increase in the number of immunosuppressed individuals living in the community and the marked increase in the number of those of advanced age (aged >80 years). Clustering of these individuals in retirement villages or nursing homes has led to a new entity: nursing home–acquired pneumonia.

Additional host factors that influence the outcome of infection are just beginning to be understood. These include the observation that 50% of patients with bacteremic pneumococcal pneumonia, as compared with 29% of uninfected control subjects, were homozygous for FcγRIIa-R31, which binds weakly to $IgG_2$ [36].

*Environmental factors.* There is a clear seasonal variation in the rate of pneumonia; both attack rates and mortality rates are highest in the winter months [37]. This is likely due to an interaction between viruses such as influenza virus and *S. pneumoniae,* and confinement indoors. In a squirrel monkey model, infection with influenza A virus before inoculation with *S. pneumoniae* led to a mortality rate of 75%, compared with 0% for animals with infection due to influenza virus alone [38]. The healthy, retired elderly travel a lot and thus may develop, for example, legionnaires disease while on a cruise ship (due to exposure to a contaminated decorative water fountain) or melioidosis during a visit to Southeast Asia.

*Microorganism-related factors.* Pneumococci for which the MIC of penicillin is <0.1 μg/mL are defined as penicillin-susceptible; those for which the MIC is 0.1–1.0 μg/mL are intermediately susceptible; and those for which the MIC is >1.0 μg/mL are highly resistant [39]. In many publications the latter 2 categories are combined into the category "penicillin-nonsusceptible" (i.e., comprising isolates with an MIC >0.1 μg/mL).

Penicillin-resistant *S. pneumoniae* (PRSP) is now common in most North American communities. Many of the PRSP isolates are resistant to ⩾3 antibiotic classes (multidrug resistance). In a recent review, 14% of bacteremic *S. pneumoniae* isolates were resistant to penicillin, 12% to ceftazidime, and 24% to trimethoprim-sulfamethoxazole [40]. In a study by Butler et al. [41], 740 *S. pneumoniae* isolates from sterile sites were collected during 1993–1994. Twenty-five percent of the isolates were resistant to >1 antibiotic: 3.5% were resistant to erythromycin and 5% were resistant to clarithromycin [41]. This is probably a harbinger for the future; in Madrid in 1992, 15.2% of *S. pneumoniae* isolates were resistant to erythromycin [42].

Fortunately, it is possible to predict who is likely to have pneumonia due to PRSP. Previous use of β-lactam antibiotics, alcoholism, noninvasive disease, age <5 or >65 years, immunosuppression, and residence in a nursing home are risk factors for PRSP pneumonia [43–46]. Outbreaks of influenza [47] and infections due to respiratory syncytial virus [48], *S. pneumoniae* [45], and *Chlamydia pneumoniae* [49] occur in nursing homes. Loeb et al. [50] carried out prospective surveillance and a retrospective audit of outbreak records in 5 nursing homes in the Toronto area over 3 years. They prospectively identified 16 outbreaks involving 480 of 1313 residents (36%), and another 30 outbreaks involving 388 residents were identified retrospectively. Outbreak pathogens included influenza virus, parainfluenza virus, respiratory syncytial virus, *Legionella sainthelensi*, and *C. pneumoniae*. Pneumonia developed in 15% of the 480 residents, and 12% required transfer to the hospital. Thirty-seven (8%) died. In addition, colonization with methicillin-resistant *Staph-*

**Table 2.** Risk factors for nursing home–acquired pneumonia [23, 24].

| Risk factor | Description |
|---|---|
| Profound disability | Karnofsky score <10 |
| Bedridden | — |
| Urinary incontinence or deteriorating health status | — |
| Old age | OR, 1.7 |
| Male sex | OR, 1.9 |
| Difficulty swallowing | OR, 2.0 |
| Inability to take oral medications | — |

**Table 3.** Predictors of a fatal outcome of community-acquired pneumonia in the elderly [25, 26].

| |
|---|
| Bedridden before onset of pneumonia |
| Temperature ≤37°C |
| Swallowing disorder |
| Respiratory rate ≥30 breaths/min |
| Creatinine level >1.4 mg/dL |
| Involvement of ≥3 lobes evident on chest radiograph |
| Rapid spread of pneumonia evident radiographically |
| Immunosuppression |
| Acute renal failure |
| Acute physiology and chronic health evaluation (APACHE) II score ≥22 |

*ylococcus aureus* and gentamicin and/or ceftriaxone-resistant gram-negative bacilli are also common among residents of some nursing homes [51].

*Etiology.* Although there are well over 100 microorganisms that can cause pneumonia, only a few (*S. pneumoniae, Haemophilus influenzae, S. aureus, C. pneumoniae*, Enterobacteriaceae, *Legionella* species, influenza viruses, and respiratory syncytial virus) cause most of the cases of pneumonia. The rank order of the causes of pneumonia changes according to the severity of illness, which is usually reflected in the chosen site of care: home, hospital ward, hospital intensive care unit, or nursing home. *Mycoplasma pneumoniae* is the most commonly identified etiologic agent in younger patients treated on an ambulatory basis, accounting for 24% of the cases [52–55]. *S. pneumoniae* pneumonia is probably underdiagnosed in outpatients, since a diagnostic workup is rarely done.

In published data, *S. pneumoniae* accounts for ~5% of the cases of ambulatory pneumonia. In reality, the proportion is probably closer to 50%. A compilation of data from 9 comprehensive studies of the etiology of CAP among 5225 patients requiring hospitalization identified *S. pneumoniae* as the etiologic agent in 17.7% of cases [56–64]. However, if one focuses on the 3 studies that used serological methods in addition to blood and sputum culture to identify *S. pneumoniae*, then this microorganism accounted for up to 50% of the cases of CAP [56, 57, 62].

Ruiz et al. [65] examined the impact of age on the etiology of pneumonia and concluded that an age of ≥60 years was not associated with any discernible effect on microbial etiology; however, patients aged <60 years significantly more frequently had CAP caused by an atypical pathogen, especially *M. pneumoniae*. Woodhead et al. [66] reviewed 11 studies that reported on the etiology of pneumonia in the elderly and compared them to 3 studies of pneumonia in younger populations. The proportion of cases due to *H. influenzae, S. aureus*, and gram-negative bacilli was higher among the elderly, and the proportion due to *Legionella* and other atypical pathogens was higher among the younger patients.

The etiology of nursing home–acquired pneumonia is not well established, since these studies have relied almost entirely on the results of sputum cultures. The problem is distinguishing colonization from infection, especially when aerobic gram-negative bacilli such as *Escherichia coli, Klebsiella* species, *Proteus* species, *Enterobacter* species, and *Pseudomonas aeruginosa* are identified. Colonization of the oropharyngeal mucosa with aerobic gram-negative bacilli increases with increasing age and is especially common among residents of nursing homes [67]. *S. pneumoniae* is the most commonly identified agent in patients with nursing home–acquired pneumonia. In 6 studies of 471 patients with nursing home–acquired pneumonia, *S. pneumoniae* accounted for most (12.9%) of the cases, followed by *H. influenzae* (6.4%), *S. aureus* (6.4%), *Moraxella catarrhalis* (4.4%), and aerobic gram-negative bacilli (13.1%) [61, 68–72].

Nursing home residents account for 20% of cases of tuberculosis in older people [2]. In studies carried out in the 1980s, Stead et al. [73] found that 12% of persons entering a nursing home were tuberculin-positive and that active tuberculosis developed in 1% of isoniazid-treated tuberculin-positive patients, compared with 2.4% of those who did not receive isoniazid. Outbreaks of tuberculosis do occur in this setting [74], and the incidence of active tuberculosis among nursing home patients is 10–30 times greater than among elderly adults [2] living in the community.

## Management of CAP

The key variables about which decisions must be made for successful treatment of CAP are as follows: the site of care, the diagnostic workup, empirical antimicrobial therapy, whether and when to switch from iv to oral antibiotic therapy, conditions for discharge, and follow-up.

*Site of care.* The site of care for optimal management is dictated by the severity of the pneumonia, which can be indicated by a severity-of-illness score. Fine et al. [75] developed a pneumonia-specific severity-of-illness score derived from 20 different items (3 demographic features, 5 comorbidity features, 5 physical examination findings, and 7 laboratory data items). Points are assigned to each feature and totaled. Patients are then placed into 1 of 5 risk classes. Those in risk classes I to III are at low risk (<1%) for mortality, whereas the mortality for those in class IV is 9%, and for those in class V, 27%. In general, patients in classes I–III can be treated at home, whereas those in classes IV and V should be admitted. Fine's prediction rule has limitations: it predicts mortality and thus was not specifically designed as an admission guideline, and it does not take into account other factors that may be important in the decision to admit an elderly patient, such as the caregivers' need for a respite.

A British Thoracic Society study found that for 453 adults who required admission to the hospital for treatment of CAP, there was a 21-fold increased risk of death if 2 of the following 3 features were noted: respiratory rate ≥32 breaths/min, diastolic blood pressure ≤60 mm Hg, and blood urea nitrogen level >7 mM/L [76]. In another study, the same group noted that 72% of 60 patients admitted to the intensive care unit (35%

were aged >65 years) had ⩾2 of these features [77]. The investigators concluded that this rule, in conjunction with careful assessment of confused or hypoxic patients, should identify the majority of patients with severe CAP.

Conte et al. [78] derived a prognostic rule for elderly patients with CAP. They assigned a score of 1 to the following factors: age of >85 years, impaired motor response (failure to exhibit a motor response to verbal stimuli; localization of painful stimuli alone; flexion withdrawal; decorticate/decerebrate posturing; or no response), and increased serum creatinine concentration; they assigned a score of 2 to comorbidity and vital sign abnormality. They defined 4 stages: a score of 0 was associated with mortality rate of 4%; a score of 1–2, 11%; a score of 3–4, 23%; and a score of ⩾5, 41%. Ewig et al. [79] validated Fine's prediction rule in a population of 168 elderly patients with CAP. They found that the rule accurately predicted length of stay, the requirement for intensive care unit admission, and the risk of death due to pneumonia.

Mylotte et al. [80] carried out a retrospective chart review of 158 episodes of nursing home–acquired pneumonia: 100 were treated in the hospital and 58 were treated in the nursing home. Fine's severity-of-pneumonia scoring was applied to both groups, and the 30-day mortality rate was the same in both. The potential of the Fine scoring system [75] is demonstrated by a study by Atlas et al. [81], who prospectively enrolled 166 low-risk patients with pneumonia presenting to an emergency department. Physicians were given the pneumonia-severity index score of each patient and were offered enhanced visiting-nurse services and the antibiotic clarithromycin. Two groups of control subjects were used: 147 consecutive retrospective control subjects identified during the previous year and 208 patients from the study hospital who participated in the Pneumonia Patient Outcomes Research Team cohort study. The percentage of patients initially treated as outpatients increased from 42% in the control period to 57% in the intervention period (36% relative increase; $P = .01$). More outpatient therapy failed in the intervention period (9%) than in the control period (0%).

Marrie et al. [82] enrolled 20 Canadian teaching and community hospitals in a study of a critical pathway for the management of CAP. Ten hospitals were randomized to the intervention arm (critical pathway) and 10 to conventional management. Hospitals were matched for teaching or community hospital status and for historical length of stay for patients with CAP. One teaching hospital in the intervention arm withdrew after randomization and was not replaced. Levofloxacin was the antibiotic used in the intervention arm, whereas antimicrobial therapy for patients in the conventional arm was at the discretion of the attending physician. The pneumonia-specific severity-of-illness score was considered in the decision about site of care. An intent-to-treat analysis was performed on data from 1753 patients enrolled in the study. At the intervention hospitals, the admission rate was lower for low-risk patients (classes I–III) than it was with conventional management (31% vs. 49%; $P = .013$). To use the terminology of Atlas et al. [81], 69% in the intervention arm, compared with 41% in the conventional management arm, were treated at home. Follow-up of these patients revealed that there was no difference in the failure rates of outpatient therapy: ~6% of patients in both groups required subsequent admission.

*Treatment in the nursing home.* A study by Degelau et al. [83] offers guidance regarding who can be treated in a nursing home for pneumonia. They found that the following characteristics were associated with treatment failure in the nursing home: a pulse rate >90 beats/min; temperature >38.1°C; respiratory rate >30 breaths/min; feeding tube dependence; and mechanically altered diet. If none of the above risk factors were present, the failure rate was 11%; if ⩽2 were present, it was 23%; and when ⩾3 were present, it was 59%. The model was not predictive of mortality. Medina-Walpole and Katz [2], in a review of nursing home–acquired pneumonia, concluded that the following could be used as indicators for hospitalization: respiratory distress; dependence on others for activities of daily living; low body temperature; decreased level of consciousness; and WBC count <5 or $>20 \times 10^9$ cells/L.

Naughton and Mylotte [84] treated 171 (72%) of 239 episodes of nursing home–acquired pneumonia in the nursing home. There was no significant difference in 30-day mortality rates between those initially treated in nursing homes (22%) and those initially treated in hospitals (31%) or between those treated with an oral regimen in the nursing home (21%) and those initially treated with an intramuscular antibiotic in the nursing home (25%).

There is great variation in the organization of care within nursing homes. Those with special care units and ready access to physicians are less likely to transfer patients to hospitals for acute episodes of illness [85]. Nevertheless, there are enough data from the various studies cited above to make recommendations as to who can be safely treated in a nursing home; these recommendations are summarized in table 4. It is important to emphasize that the facility must have appropriately trained nursing staff experienced in caring for acutely ill patients/residents, physicians willing to care for residents in a long-term-care facility on a daily basis, ready access to facilities for appropriate laboratory and radiological studies, and the capacity to administer parenteral medications and provide such means of supportive care as oxygen and suctioning. In other words, to the criteria listed in table 4 must be added the availability

**Table 4.** Recommended criteria for treatment of a nursing-home resident with pneumonia.

| |
|---|
| Respiratory rate <30 breaths/min |
| Oxygen saturation ⩾92% while breathing room air |
| Pulse rate <90 beats/min |
| Temperature 36.5°C to 38.1°C |
| No feeding tube present |
| Conscious |

of the proper physical and human resources to care for these patients in the nursing home.

*Admission to intensive care unit.* The American Thoracic Society guidelines for the management of CAP give criteria for severe pneumonia that could be useful in deciding whether to admit a patient to an intensive care unit [86]. Ewig et al. [87] calculated the sensitivity, specificity, and positive and negative predictive values of these criteria with use of data from a prospective study of 422 consecutive patients with CAP, 64 of whom were admitted to an intensive care unit. They found that no single criterion was of sufficient sensitivity to use alone. For example, a respiratory rate of >30 breaths/min had a sensitivity of 64% and a specificity of 57%. The respective sensitivity and specificity values for other characteristics were as follows: requirement for mechanical ventilation, 58% and 100%; septic shock, 38% and 100%; progressive pulmonary infiltrates, 28% and 92%; renal failure, 30% and 96%; systolic blood pressure <90 mm Hg, 12% and 99%; diastolic blood pressure <60 mm Hg, 15% and 95%; bilateral infiltrates, 41% and 86%; and multilobe infiltrates, 52% and 89%.

The investigators concluded that definition of severe pneumonia with use of 1 of the American Thoracic Society criteria had a sensitivity of 98%, a specificity of 32%, a positive predictive value of 24%, and a negative predictive value of 99%. These authors developed a new rule for identifying severe pneumonia on the basis of the presence of 2 of 3 minor criteria (partial pressure of arterial $O_2$/fraction of inspired $O_2$ <250 mm Hg; multilobar involvement; systolic blood pressure of ≤90 mm Hg) plus 1 of 2 major criteria (septic shock or mechanical ventilation). They noted that this rule had a sensitivity of 78%, a specificity of 94%, and a positive predictive value of 75%. Age alone is not a consideration in the decision to not admit a patient with pneumonia to an intensive care unit.

*Diagnostic workup.* The extent of the diagnostic workup for patients with pneumonia depends upon the severity of the pneumonia. For otherwise healthy patients who are going to be treated on an ambulatory basis, a chest radiograph to confirm the clinical diagnosis is all that is necessary; however, for elderly patients, who often have comorbidities for which they are receiving medication, a complete blood cell count and measurements of electrolytes and serum creatinine are usually indicated. All patients who require admission to the hospital for treatment of CAP should undergo chest radiography. The limitations of chest radiography for diagnosis of pneumonia in the elderly should be noted. Often all that is available is a portable anteroposterior film of suboptimal quality. The Pneumonia Patient Outcomes Research Team study of CAP found that 2 staff radiologists agreed on the presence of a pulmonary infiltrate in 79.4% of 282 patients with clinically diagnosed pneumonia whose films had already been read (and interpreted as indicative of pneumonia) by a study-site radiologist, and the 2 radiologists agreed on the absence of an infiltrate in 6% of patients [88].

In one study, chest radiography was compared to high-resolution CT for the diagnosis of CAP [89]. Chest radiographs detected an opacity in 18 of 47 patients (38.3%) suspected of having pneumonia, whereas high-resolution CT detected opacities in these 18 patients and in an additional 8 (55.3%) [89]. All patients who are admitted to the hospital should have blood cultures performed, even though only 6%–10% of patients with CAP will be bacteremic [56–64]. The reason for this recommendation is that a blood culture positive for a pathogen is definite evidence that the microorganism is causing the pneumonia. Such isolates (60% will be *S. pneumoniae*) provide useful epidemiological information that can be used to track trends in antimicrobial resistance, and for the clinician it allows for change to more-specific antimicrobial therapy.

Gram staining of a good sputum specimen (<10 squamous epithelial cells per low-powered field; >25 WBCs per low-powered field) is useful for directing initial antibiotic therapy (e.g., a good specimen that is gram-positive for diplococci suggests a diagnosis of pneumococcal pneumonia, thus allowing more specific antibiotic therapy); thus, an attempt should be made to collect such a specimen. The limitations of expectorated sputum must be recognized by the clinician, especially for the elderly, in whom oropharyngeal colonization with aerobic gram-negative bacilli is common, so that differentiating colonization from infection may be difficult. Bronchoscopy is not uncommonly performed on patients with pneumonia who require admission to an intensive care unit. In such instances, samples of lower respiratory tract secretions should be obtained with a protected bronchial brush or bronchoalveolar lavage. Rarely an open-lung biopsy is required.

Serological studies are not recommended routinely. However, if certain etiologic agents such as *Coxiella burnetii, M. pneumoniae, C. pneumoniae,* or a virus are suspected, serological tests of acute and convalescent serum samples can aid in the diagnosis. Unfortunately, the results of these studies are not available for 3–4 weeks, by which time the clinical situation has been resolved. These studies are helpful for public health purposes and should always be performed in workups during an outbreak of pneumonia. A urine specimen for detection of *Legionella* antigen is useful in all cases of severe pneumonia. Currently available tests detect only *Legionella pneumophila* serogroup 1 antigen (which accounts for ~80% of cases of legionnaires disease) [90, 91], but a test capable of detecting antigens of other *L. pneumophila* serogroups should be available shortly.

PCR has been used to amplify DNA of various pneumonia pathogens from nasopharyngeal samples, lung tissue samples, and WBCs. Currently, PCR is not recommended for routine use.

*Empirical antibiotic therapy.* The American Thoracic Society [86] and the Infectious Diseases Society of America have published guidelines for the empirical treatment of CAP [92] (table 5). The recent introduction of quinolones with enhanced activity against *S. pneumoniae* and activity against most of the

**Table 5.** Antibiotic therapy (choices in order of preference) for community-acquired pneumonia when the etiology is unknown (modified from [84] and [92]).

| Type of patient, recommended therapy |
|---|
| Patient to be treated on an ambulatory basis[a] |
| Macrolide (erythromycin [500 mg q6h po × 10 d], clarithromycin [500 mg b.i.d. po × 10 d], or azithromycin [500 mg po once, then 250 mg o.d. po × 4 d]) |
| Doxycycline (100 mg b.i.d po × 10 d) |
| Patient to be treated in hospital ward |
| Fluoroquinolone with enhanced activity against *S. pneumoniae*, e.g., levofloxacin (500 mg o.d. iv or po) or sparfloxacin (400 mg × 1 dose, then 200 mg o.d. po). If creatinine clearance is <50 mL/min, reduce levofloxacin dosage to 250 mg o.d., or use moxifloxacin (400 mg o.d. po) or gatifloxacin (400 mg o.d. iv or po) |
| Cefuroxime (750 mg q8h iv) or ceftriaxone (1 g o.d. iv) or cefotaxime (2 g q6h iv) plus azithromycin (500 mg o.d. iv) |
| Patient to be treated in an intensive care unit |
| Azithromycin (1 g iv, then 500 mg iv o.d. q24h) plus ceftriaxone (1 g q12h iv) or cefotaxime (2 g q6h iv). Use cefipime and ciprofloxacin or imipenem and ciprofloxacin if *Pseudomonas aeruginosa* is suspected. |
| Fluoroquinolone with enhanced activity against *S. pneumoniae* (not recommended as first choice because of lack of clinical trial data from this setting) |
| Patient to be treated in a nursing home |
| Amoxicillin clavulanic acid (500 mg q8h po) |
| Fluoroquinolone with enhanced activity against *S. pneumoniae* (e.g., levofloxacin [500 mg o.d. po]) |
| Ceftriaxone (500–1000 mg im o.d.) or cefotaxime (500 mg im q12h) |
| Patient with aspiration pneumonia |
| Large-volume aspiration in a previous healthy individual: no antibiotic therapy |
| Small-volume aspiration |
| In a patient with pneumonia (and poor dental hygiene), in whom anaerobic infection is suspected: clindamycin or penicillin |
| In a patient with pneumonia who lives in a nursing home or is elderly and lives at home: amoxicillin/clavulanic acid plus a fluoroquinolone |

[a] Consider administration of a fluoroquinolone with enhanced activity against *S. pneumoniae* if the patient has risk factor(s) for infection with penicillin-resistant *S. pneumoniae* (previous use of $\beta$-lactam antibiotics, alcoholism, age <5 or>65 years, and/or, in some areas, residence in a nursing home) or infection with macrolide-resistant *S. pneumoniae* (age <5 years or nosocomial acquisition of infection).

pathogens that cause CAP is an advance in the treatment of CAP. However, there are many unanswered questions regarding these new drugs. Which one is best? Should they be used only for patients with pneumonia who require hospitalization? Will widespread use of the new fluoroquinolones for the treatment of ambulatory pneumonia lead to the emergence of resistance among *S. pneumoniae*?

The new fluoroquinolones are levofloxacin, sparfloxacin, grepafloxacin, trovafloxacin, gatifloxacin, and moxifloxacin. Grepafloxacin and trovafloxacin have been withdrawn from the market—the former because of QT interval prolongation resulting in torsade de pointes and the latter because of hypersensitivity hepatitis, some cases of which were fatal. The advantages of the new fluoroquinolones include excellent bioavailability, so that even hospitalized non–intensive care unit patients can be treated orally (if they can eat and drink), and activity against the spectrum of agents that cause CAP, so that only one antibiotic is necessary for the empirical treatment of patients with CAP.

Another major issue concerning the empirical treatment of CAP is what to do about penicillin-resistant *S. pneumoniae* strains. One study concluded that these pathogens are less virulent than penicillin-susceptible strains but do result in increased length of stay [93], whereas another concluded that the clinical outcome of penicillin-nonsusceptible infections outside the CNS may be more closely related to the clinical condition at presentation than to the level of resistance of the causative strain when such infections are treated with $\beta$-lactam antibiotics [94]. However, Metlay et al. [95], using data from a 1994 study of invasive pneumococcal infection in Atlanta, showed that the relative risk for death among those without HIV infection who were infected with penicillin-nonsusceptible *S. pneumoniae* rather than penicillin-susceptible *S. pneumoniae* was 1.5 (range, 0.6–3.3), whereas for those with HIV infection it was 11.7 (1.3–10.2).

Leikin et al. [96] studied 5837 patients with invasive pneumococcal pneumonia. Increased mortality was not associated with resistance to penicillin or cefotaxime; however, when deaths during the first 4 hospital days were excluded, mortality was significantly associated with a penicillin MIC of ⩾4 mg/L and a cefotaxime MIC of ⩾2 mg/L. Despite this, the general consensus is that for infections in which the CNS is involved, treatment with penicillin or a second- or third-generation cephalosporin is adequate (ceftazidime is not recommended because of poor activity against *S. pneumoniae*). Another issue is the empirical use of oral macrolides, given that macrolide resistance among *S. pneumoniae* in some areas is high. Despite this, there is a paucity of data regarding clinical failures of macrolide

therapy [97]. Amsden [97] tried to explain this by showing adding serum to antibiotic-susceptibility-testing media decreases the MIC for macrolides by 1–2 dilutions (hence, in vivo MICs will be lower than in vitro MICs) and by showing that these agents are concentrated in WBCs, which are attracted to the site of the infection

One of the problems with the recommendations listed in table 4 is that they are based mostly on expert opinion. Data are now emerging that can be used to give future guidelines more of an evidence-based approach. Early administration of antibiotics affects outcomes. Thus, Meehan et al. [98] carried out a retrospective multicenter cohort study of those aged >65 years who presented to emergency departments with CAP. The investigators used the Medicare National Claims History File from 1 October 1994 through 30 September 1995. Just over 75% of patients received antibiotics within 8 h of presenting at the emergency department, and a significantly lower 30-day mortality rate was observed for them than for those who did not receive antibiotic therapy within 8 h.

Gleason et al. [99] reviewed the hospital records of 12,945 Medicare patients hospitalized for treatment of CAP and found that initial therapy with a second-generation cephalosporin plus a macrolide, a nonpseudomonal third-generation cephalosporin plus a macrolide, or a fluoroquinolone alone was independently associated with a lower 30-day mortality than was therapy with a nonpseudomonal third-generation cephalosporin alone. Use of a $\beta$-lactam/$\beta$-lactamase inhibitor plus a macrolide or an aminoglycoside plus another agent was associated with higher 30-day mortality.

*Switch from iv to oral antibiotic therapy and duration of therapy.* In a series of studies, Ramirez and colleagues defined criteria for switching from iv to oral antibiotics for treatment of patients with CAP [100, 101]. These include (1) 2 normal temperature readings on 2 occasions, 8 h apart, for previously febrile patients; (2) WBC count returning toward normal; (3) subjective diminishment of cough; and (4) subjective diminishment of shortness of breath. On the basis of these criteria, 33 patients randomized to ceftizoxime therapy were eligible for the switch to oral therapy in 2.76 days, compared with 3.17 days for those randomized to receive ceftriaxone [100]. Seventy-four of the 75 evaluable patients were cured at 3–5-week follow-ups. Similar results were obtained in another study by this group, in which patients were initially treated with ceftriaxone and, when the criteria were met, were switched to clarithromycin therapy orally. Ninety-six patients were enrolled in this study, and 59 were evaluable at the 30-day follow-up. All 59 were cured [101].

The presence of bacteremia and the identification of high-risk pathogens such as *S. aureus* or *P. aeruginosa* are not contraindications for switching therapy [102]. Patients whose conditions are clinically improving with empirical third-generation cephalosporin therapy are switched to oral third-generation cephalosporins, whereas patients who are receiving $\beta$-lactam/$\beta$-lactamase inhibitor agents are switched to oral $\beta$-lactam/$\beta$-lactamase inhibitors. If iv therapy is a $\beta$-lactam antibiotic and erythromycin, oral therapy should be a new macrolide [102].

The optimal total duration of antibiotic therapy for CAP has not been defined in prospective studies. Studies should be carried out to determine if a longer duration of therapy is necessary for elderly patients. Since about half the patients with CAP have respiratory symptoms at a 30-day follow-up, it is possible that longer therapy than that given at present may be beneficial. By convention, 10–14 days is the usual duration of therapy. Legionnaires disease should be treated for 21 days, as should pneumonia due to *Pneumocystis carinii*.

*Decision to discharge.* Halm et al. [103] investigated how long it took patients hospitalized with CAP to achieve stability. The median time to stability was 2 days for heart rate ($\leqslant$100 beats/min) and systolic blood pressure ($\geqslant$90 mm Hg). Three days were required to achieve stability if the following parameters were used: respiratory rate $\leqslant$24 breaths/min, oxygen saturation level $\geqslant$90%, and temperature $\leqslant$37.2°C. Once stability was achieved, clinical deterioration requiring admission to a critical care unit or telemetry monitoring occurred for fewer than 1% of patients. Patients in Halm's study frequently remained in the hospital $\geqslant$1 day after reaching stability. Elderly patients frequently require hospitalization beyond the time required to achieve physiological stability, in order to recover function that has declined during the acute illness.

*Follow-up.* All elderly patients with CAP should undergo follow-up chest radiography to make sure that the pneumonia has resolved. Pneumonia distal to an obstructed bronchus is one of the presentations of cancer of the lung; for ~50% of patients with this presentation, the diagnosis of cancer is made at the time of presentation. For the remainder, the main clue to the underlying disease is the failure of the pneumonia to resolve. Radiographic resolution of pneumonia lags behind clinical resolution and correlates with age and the presence of chronic obstructive lung disease. In one study, radiographic resolution occurred after $\geqslant$12 weeks in patients with bacteremic pneumococcal pneumonia who were aged >50 years, had coexistent chronic obstructive lung disease, and or were alcoholics [104]. If you have reason to suspect an underlying malignancy in a patient, perform follow-up chest radiography in 4–6 weeks; otherwise, the follow-up chest radiography is best performed 10–12 weeks after the diagnosis of pneumonia. If complete resolution has not occurred, further investigation to rule out an obstructed bronchus is necessary.

*Long-term outcome.* Koivula et al. [105] carried out a 12-year follow-up of the 122 residents of a Finnish township (all were aged >60 years) who survived an episode of pneumonia during 1983–1985. Thirty-nine percent of those with CAP treated on an ambulatory basis were alive at 10 years, compared with 26% of those who required hospitalization for the treatment of their pneumonia. The relative risk of mortality related to all types of CAP was 2.1, and that related to pneumococcal

pneumonia was 2.8. Hedlund et al. [106] followed 241 patients who survived CAP for 31 months and noted that 51 died, whereas the expected number of deaths was 29.5. Thus, the relative risk of death was 2. Brancati et al. [107] found that 38 of 119 patients (32%) who survived CAP died over the subsequent 24 months. Two-year mortality was independently related to severe comorbidity, for which the RR was 9.4 (moderate comorbidity had an RR of 3.1; hematocrit <35% had an RR of 2.9). However, compared with patients aged 18–44 years, those aged 45–64, 65–74, or 75–92 years were not significantly more likely to die during the 24 months after discharge. Nursing home residents were excluded from this study.

Marrie and Blanchard [108] studied 71 patients with nursing home–acquired pneumonia, 79 patients who were admitted from a nursing home for conditions other than pneumonia, and 93 elderly patients with CAP. The in-hospital mortality rates were 32%, 23%, and 14%, respectively. The 1-year mortality rates for the 3 groups were 58%, 50%, and 33%. In Muder's study [24] of 108 patients with pneumonia in a Veterans Affairs facility, the 14-day mortality was 19%; 12-month mortality, 59%; and 24-month mortality, 75%. Functional status was the major determinant of survival following pneumonia: at 24 months, the mortality rates for various activities-of-daily-living scores were as follows: score ⩽10, 48% mortality; score 11–15, 75%; and score ⩾16, 77% [24].

## Issues that Are Especially Significant When Treating Elderly Patients with Pneumonia

*Functional assessment.* It is useful to quantify the level of function of your elderly patients with use of Barthel's index [109] and or the hierarchial assessment of balance and mobility [110, 111]. The former scores 15 factors that are rated by the patient as follows: can do by myself, can do with help of someone else, and cannot do at all. The total score can range from 0 (total dependence) to 100 (complete independence). A score ⩽40 defines those who are severely dependent, whereas a score of 41–60 indicates marked dependence. The hierarchical assessment of balance and mobility separates mobility into 3 categories—mobility, transfers, and balance—and constructs a hierarchical range of abilities in each section.

*Referral to geriatric assessment team and restorative care.* Elderly patients who are functionally impaired (the frail elderly [112]) should be referred for geriatric assessment. Some of these patients may require admission to a geriatric rehabilitation center after the pneumonia has resolved. Studies have shown that geriatric assessment teams do improve the care of the elderly, resulting in a reduction in the number of patients who need discharge to long-term-care institutions [113]. However, such assessment with only limited follow-up has not been effective [114].

*Do-not-resuscitate status.* An in-depth discussion of do-not-resuscitate (DNR) issues is beyond the scope of this article. In a study of the epidemiology of DNR orders, Wenger et al. [115] noted that more DNR orders were received for patients with greater sickness at admission and functional impairment. DNR orders were assigned more often to older patients, women, and patients with dementia or incontinence and were assigned less often to black patients, patients with Medicaid, and patients treated in rural hospitals. The high in-hospital mortality rates and the presence of comorbidities that often indicate the futility of resuscitation efforts dictate that physicians who manage pneumonia in elderly patients should be aware of any advance directives that their patients may have made. In the absence of such a directive, the issue of resuscitation should be discussed with the patient and his or her next of kin early in the hospital stay. Many hospitals require that the resuscitation status of such patients be indicated on the order sheet at the time of admission.

*Nutritional assessment.* From the age of 30 years to the age of 80 years, energy expenditure decreases by one-third [116]. However, the requirements for protein intake do not [116]. Malnutrition has been identified as a risk factor for development of CAP in the elderly [25]. A recent study of malnutrition in hospitalized elderly patients with CAP showed that only 16% of the 101 patients studied were characterized as well-nourished at the time of hospital admission, in comparison to 47% of the control population [6]. Many factors combine to compromise the nutritional state of elderly individuals and, in turn, this compromise potentiates immune dysregulation and can perpetuate or aggravate ongoing disease processes such as pneumonia.

The quality of the diet in the aging population is influenced by physiological factors such as poor dentition, altered taste acuity, limited mobility, and polypharmacy. Persons aged 74–80 years have fewer than 100 taste buds, whereas young adults have 250 [117]. Psychological factors in this group that can contribute to poor oral intake include depression, dementia, and lack of motivation. Social factors that further compromise dietary intake include institutionalization, living alone, isolation during meals, and poor education. Similarly, in an aging population, economic factors such as reduced income, inadequate cooking, and health care costs can affect the quality of the diet [118].

It is important to be able to identify nutritional risk in an elderly person who presents with CAP. The cornerstone of identifying nutritional risk is obtaining a weight history. Weight loss of >10% of usual weight is associated with a very high mortality rate and is considered significant. A loss of 5%–10% of usual weight is considered potentially important. Loss of <5% of usual weight is considered not to be significant [119]. Another way to determine body composition and nutritional status is to consider the body mass index ([weight in kg/height in m]$^2$). A body mass index of 21–25 is considered normal.

In the previously cited study by Riquelme et al. [6], the patients with CAP at the time of enrollment in the study had an average body mass index of 22.8, which was significantly lower

than that of the control group (24.3; $P = .043$). This would suggest that a lower body mass index is associated with an increase in nutritional risk and, ultimately, an increased risk of CAP. Serum albumin level is commonly cited as a marker of nutritional status, and it has been correlated independently with a higher case-fatality rate among persons with CAP [120]. Although serum albumin level is an indicator of nutritional status, experimental and clinical data indicate that in inflammatory disorders the synthesis of acute-phase proteins occurs at the expense of albumin, and thus a low serum albumin level can be caused by both malnutrition and the acute inflammatory response.

Hedlund et al. [120], in a study of 97 patients with pneumonia, found that a low triceps skin-fold thickness, low body mass index, and high acute physiology and chronic health evaluation (APACHE) II score correlated with death within 6 months.

*Impaired renal and hepatic function.* The elderly have impaired function of many organs by virtue of the aging process and as a result of comorbidity. Physicians should pay careful attention to drug dosages and drug interactions in this group of patients.

*Prevention of the next episode of pneumonia.* Those who are at risk for aspiration should be positioned at a 45° angle when eating and should receive pureed foods. Nasogastric or percutaneous gastrostomy feeding tubes do not prevent aspiration and indeed may predispose to it, unless protocols to prevent aspiration in these settings are followed.

Both influenza and pneumococcal vaccinations have been shown to be beneficial in the prevention of pneumonia in the elderly [121–128]. Vaccination of the elderly will be covered in a later article in this series. Since tobacco smoking increases the risk of pneumonia, all tobacco smokers should be given advice and help to stop smoking.

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