Testing Strategies in the Initial Management of Patients with Community-Acquired Pneumonia

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The initial management of patients suspected of having community-acquired pneumonia is challenging because of the broad range of clinical presentations, potential life-threatening nature of the illness, and associated high costs of care. The initial testing strategies should accurately establish a diagnosis and prognosis in order to determine the optimal treatment strategy. The diagnosis is important in determining the need for antibiotic therapy, and the prognosis is important in determining the site of care.

This paper reviews the test characteristics of the history, physical examination, and laboratory findings, individually and in combination, in diagnosing community-acquired pneumonia and predicting short-term risk for death from the infection. In addition, we consider the implications of these test characteristics from the perspective of decision thresholds. The history and physical examination cannot provide a high level of certainty in the diagnosis of community-acquired pneumonia, but the absence of vital sign abnormalities substantially reduces the probability of the infection. Chest radiography is considered the gold standard for pneumonia diagnosis; however, we do not know its sensitivity and specificity, and we have limited data on the costs of false-positive and false-negative results. In the absence of empirical evidence, the decision to order a chest radiograph needs to rely on expert opinion in seeking strategies to optimize the balance between harms and benefits. Once community-acquired pneumonia is diagnosed, a combination of history, physical examination, and laboratory items can help estimate the short-term risk for death and, along with the patient’s psychosocial characteristics, determine the appropriate site of treatment.

METHODS

This paper is expanded from two previous systematic reviews of the diagnosis (4) and prognosis (5) of community-acquired pneumonia (5). We updated our publication database by including updated search strategies from MEDLINE from January 1996 through December 2000 (search strategies available upon request) and reviewing the references from all retrieved new articles.

Articles on the Diagnosis of Community-Acquired Pneumonia

We emphasized studies with consecutive series of patients suspected of having pneumonia who had a chest radiograph regardless of the results of diagnostic testing and had it interpreted without knowledge of the other clinical findings (6). We excluded articles that did not report findings for patients with and without pneumonia. We excluded studies of children and inpatients and studies that did not obtain chest radiographs in all patients suspected of having community-acquired pneumonia.

We abstracted the total number of persons studied and the number of true-positive, true-negative, false-positive, and false-negative results for each diagnostic test, using the results of chest radiography as the gold standard. Because of the heterogeneity in study designs, we did not pool data. Instead, we calculated positive and negative likelihoods for each finding in each study. We report the range of likelihood ratios only for findings that were statistically signifi-
Diagnosis of Pneumonia

Community-acquired pneumonia is defined as an acute infection of the lung parenchyma accompanied by symptoms of acute illness. Patients who acquire the infection in hospitals or long-term care facilities are typically excluded from the definition (2). The gold standard for diagnosing community-acquired pneumonia should be the identification of a microbiological pathogen isolated directly from the lung tissue. However, such a test (for example, lung puncture or biopsy) is rarely undertaken for the routine diagnosis of community-acquired pneumonia. An alternative gold standard could be based on a combination of clinical symptoms; radiographic, laboratory, and microbiological findings; and clinical response to antimicrobial therapy. However, in both clinical and research settings, isolated findings on chest radiography are often interpreted as the gold standard for the initial diagnosis of pneumonia even though chest radiography is neither 100% sensitive nor 100% specific for this condition.

In terms of sensitivity, pneumonia can be present in the absence of an infiltrate on chest radiography at the time of diagnosis. However, the occurrence of this phenomenon has only limited support in the published literature. In an independent, blinded comparison of chest radiography with high-resolution computed tomography, chest radiography missed 8 of 26 (31%) cases of possible pneumonia that were identified on high-resolution computed tomography as any opacification or consolidation compatible with acute-phase lung involvement (10). While many of these missed cases had clinical and laboratory evidence of acute infection, it is not correct to assume that the sensitivity of chest radiography is as low as 69%, because these additional cases were not validated as true cases of community-acquired pneumonia based on microbiological evidence or response to antibiotic therapy. Dehydration may play an important role in the occurrence of pneumonia without findings on chest radiography (11), and a recent study suggests that patients with signs of dehydration on admission are more likely to have worsening chest radiographs over several days compared with patients without these signs (12).

Thus, chest radiography is an imperfect gold standard test. The effect of these test characteristics on the decision to perform chest radiography depends on the pretest probabilities of the infection and the relative costs of over- and underdiagnosis of this infection. In the next section, we consider the effect of history and physical examination findings on the pretest probability of community-acquired pneumonia.

Prevalence of Pneumonia in Patients

The probability of pneumonia before the ordering of additional diagnostic testing depends on the clinical setting and the results of the medical history and physical examination. We examine the influence of each factor independently and then in combination.

Clinical Setting

The prevalence of pneumonia in patient populations presenting with acute respiratory illnesses varies substantially across study samples. In one study that examined consecutive patients with acute respiratory symptoms presenting to emergency departments and outpatient medical clinics, the prevalence of radiographically confirmed pneumonia was 7% (13). In a study examining patients with acute cough presenting to a military emergency department, the prevalence was only 2.6% (14). Recently, a prospective study of previously well adults (that is, no history of chronic lung or heart disease) with acute cough illness presenting to general practitioners in the United Kingdom found that 6% of patients met criteria for radiographic pneumonia (15). In contrast, in a recent study of patients presenting to a Veterans Affairs hospital with acute cough...
and change in sputum, 24 of 52 patients (46%) had chest radiographs consistent with pneumonia (16). However, this study included a nonconsecutive sample of predominately older male patients with underlying pulmonary and cardiac diseases. In our review of data from the National Ambulatory Medical Care Survey for 1980 to 1994, pneumonia was diagnosed in 4.7% of patients with acute cough who visited a primary care provider (17).

### Medical History

Symptoms at presentation distinguish poorly between community-acquired pneumonia and other causes of respiratory illnesses. The likelihood ratio for these findings is typically close to 1.0 (Table 1). For example, in the study that found cough to be a statistically significant predictor of pneumonia, the presence or absence of cough had likelihood ratios of 1.8 and 0.3, respectively (18). In general, the presence or absence of comorbid conditions does not have a substantial effect on the probability of pneumonia.

<table>
<thead>
<tr>
<th>Type of Finding</th>
<th>Positive Likelihood Ratio†</th>
<th>Negative Likelihood Ratio†</th>
<th>Studies, n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical history</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fever</td>
<td>1.7–2.1</td>
<td>0.6–0.7</td>
<td>2</td>
</tr>
<tr>
<td>Chills</td>
<td>1.3–1.7</td>
<td>0.7–0.9</td>
<td>3</td>
</tr>
<tr>
<td>Vital signs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tachypnea†</td>
<td>1.5–3.4</td>
<td>0.8</td>
<td>2</td>
</tr>
<tr>
<td>Tachycardia‡</td>
<td>1.6–2.3</td>
<td>0.5–0.7</td>
<td>3</td>
</tr>
<tr>
<td>Hyperthermia§</td>
<td>1.4–4.4</td>
<td>0.6–0.8</td>
<td>4</td>
</tr>
<tr>
<td>Chest examination</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dullness to percussion</td>
<td>2.2–4.3</td>
<td>0.8–0.9</td>
<td>2</td>
</tr>
<tr>
<td>Decreased breath sounds</td>
<td>2.3–2.5</td>
<td>0.6–0.8</td>
<td>2</td>
</tr>
<tr>
<td>Crackles</td>
<td>1.6–2.7</td>
<td>0.6–0.9</td>
<td>4</td>
</tr>
<tr>
<td>Rhonchi</td>
<td>1.4–1.5</td>
<td>0.8–0.9</td>
<td>2</td>
</tr>
<tr>
<td>Egophany</td>
<td>2.0–8.6</td>
<td>0.8–1.0</td>
<td>3</td>
</tr>
<tr>
<td>Laboratory findings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leukocytosis¶</td>
<td>1.9–3.7</td>
<td>0.3–0.6</td>
<td>2</td>
</tr>
</tbody>
</table>

* Only findings that were statistically significantly associated with the presence or absence of pneumonia in at least two studies were included ($P < 0.05$ in a two-tailed chi-square or Fisher exact test).
† Represents the range of significant values determined from the individual studies reporting data for each finding.
‡ Tachypnea defined as respiratory rate >25 breaths/min.
§ Tachycardia defined as heart rate ≥100 beats/min in two studies and >120 beats/min in a third study.
¶ Hyperthermia defined as body temperature >37.8 °C (100 °F).
¶ Leukocytosis defined as leukocyte count >11 × 10^9/L in one study (providing the lower bounds of each estimate) and ≥10.4 × 10^9/L in the second study.

The absence of any individual chest examination finding has little effect on the probability of pneumonia. A normal chest examination has a likelihood ratio for pneumonia of only 0.6 (19). Positive chest examination findings increase the probability of pneumonia by a small amount. For example, the finding of crackles on chest auscultation has a likelihood ratio in the range of 1.6 to 2.7 (14, 18–20) (Table 1).

By combining the baseline prevalence of pneumonia in a typical ambulatory care setting with these likelihood ratios for symptoms and signs, we can provide a guide for pneumonia probabilities in the setting of a baseline prevalence of pneumonia of 5% among patients with acute respiratory illnesses (Figure 1). For example, a patient with documented fever is expected to have a probability of pneumonia as high as 19%. Among patients with crackles on auscultation of the lungs, the probability of pneumonia ranges from 8% to 10%; for dullness to percussion, the revised probability ranges from 10% to 18%.

### Physical Examination

The effect of vital sign abnormalities on the probability of pneumonia depends on the cut-off value to define an abnormal result. For example, a respiratory rate greater than 20 breaths/min had a likelihood ratio of only 1.2 in one study (19), whereas a respiratory rate greater than 25 breaths/min had a likelihood ratio of 1.5 to 3.4 in two other studies (14, 20) (Table 1). In contrast, one study has shown that having a normal heart rate (≤100 beats/min), temperature (≤37.8 °C), and respiratory rate (≤20 breaths/min) statistically significantly reduces the probability of community-acquired pneumonia (negative likelihood ratio, 0.18), thereby reducing the pretest odds of pneumonia by more than fivefold (19).

### Combinations of History and Physical Examination Findings

These revised probabilities for individual findings are still low and are inconsistent with the clinical impression that the history and physical examination of some patients predict a much higher probability of pneumonia. In part, this discrepancy reflects the fact that physicians use combinations of signs and symptoms in developing revised probabilities of disease. Three studies have identified combinations of history and physical examination findings that statistically significantly affect the probability of pneumonia (14, 18, 20).

As a practical example of how these combinations of symptoms and signs yield revised probabilities, we apply the available prediction rules to two common clinical sce-
The effects of history and physical examination findings separately and in combination were examined in the ambulatory care setting, where the baseline prevalence of community-acquired pneumonia is 5%. Likelihood ratios derived from Table 1 were applied to the baseline prevalence by using the Bayes theorem (post-test odds = pretest odds × likelihood ratio). The range of revised probabilities depicted by the width of each bar reflects the range of likelihood ratios observed for these findings. The finding of normal vital signs requires heart rate of 100 beats/min or less, temperature of 37.8 °C or less, and respiratory rate of 20 breaths/min or less (19).

The first patient presents to an emergency department with an acute cough but has no additional signs or symptoms (vital signs and lung examination are normal). Assuming a baseline prevalence of pneumonia of 5% among all patients presenting with acute cough, the probability of pneumonia in this patient is estimated to range from 1% to 13%. (The wide range of probabilities reflects the fact that the ability of normal vital signs to rule out pneumonia was suggested by one study [19] but not confirmed in a subsequent study [13].) The second patient presents with an acute cough, fever, tachycardia, and crackles on chest examination. With a baseline prevalence of pneumonia of 5%, the revised probability of pneumonia ranges from 18% to 42% (Figure 1). If the clinical setting includes sicker patients and the baseline prevalence of pneumonia is increased to 10%, the revised probability of pneumonia ranges from 32% to 60% for a patient with cough, fever, tachycardia, and crackles.

**The Decision To Order a Chest Radiograph**

As described by Pauker and Kassirer (21) for diagnostic testing, the approach to a testing decision in patients suspected of having community-acquired pneumonia should be driven by the probability of disease, the sensitivity and specificity of the diagnostic test, the costs and harms of the diagnostic test, and the treatment threshold.

In terms of the sensitivity of chest radiography, over a broad range of values, a negative chest radiograph will not eliminate the diagnosis of pneumonia in the setting of a high pretest probability. For example, assuming perfect specificity of the test, if the pretest probability of pneumonia is 50%, a negative chest radiograph will only decrease the probability of pneumonia to 9% if the sensitivity is 90% and to 23% if the sensitivity is 70%.

The next issue to consider is the cost and harms of the test. While the costs of chest radiography are not insignificant, the harms of the test are primarily related to the inconvenience of the test rather than any specific toxicity associated with the low dose of radiation.

The final issue to consider is the treatment threshold probability, which requires a measurement of the harms plus benefits of treatment. Such a calculation is difficult, if not impossible. In terms of the benefits of therapy, while historical analyses have pointed out that the mortality rate for patients with bacteremic pneumococcal pneumonia may have decreased by as much as 60% to 70% since the advent of antibiotic therapy (22), similar data are not available for lower-risk patients, particularly those treated in outpatient settings where the current mortality rate is no more than 1% (23).

In terms of the harms of therapy, the likelihood of a serious allergic reaction is small (24), but the consequences can be grave. However, the risks from unnecessary antibiotic therapy may be more relevant at the community level rather than the individual level because antibiotic drug use increases the prevalence of resistant bacteria in the community (25). This renders groups of individuals at increased risk and makes it difficult to incorporate the risk of antibiotic therapy into decisions for individual patients.

In summary, we do not have a strong evidentiary basis for deciding when to obtain a chest radiograph. We have limited data on the sensitivity and specificity of the test, we do not know the benefits of treatment for most patient groups, and we do not know how to estimate the societal harms of treatment at an individual level. In such settings, we need to augment our recommendations with clinical wisdom, including expert group opinions published as national guidelines (for example, pneumonia treatment guidelines from the Infectious Diseases Society of America and the American Thoracic Society [2, 3]). These professional organizations endorse the need for chest radiography to confirm all diagnoses of community-acquired pneumonia.

**Alternative Laboratory Tests**

One option toward improving the problems with chest radiography as the diagnostic standard for community-acquired pneumonia is to develop and test additional diagnostic tools. The two best-studied laboratory tests for diagnosing community-acquired pneumonia are the leukocyte count and measurement of C-reactive protein. In one study (26), a leukocyte count of $10.4 \times 10^9$ cells/L or greater had a positive likelihood ratio of 3.7 (95% CI, 2.2 to 5.5) for pneumonia and a negative likelihood ratio of 0.6 (CI, 0.3 to 0.8). A C-reactive protein level of 50 mg/L or greater had a positive likelihood ratio of 5.0 (CI, 2.8 to 8.0) and a negative likelihood ratio of 0.6 (CI, 0.3 to 0.8). However, the authors chose threshold levels that corre-
sponded to a sensitivity of 50%, providing suboptimal estimates of the probability of pneumonia when the C-reactive protein level is below the cutoff value. Other studies have reported higher sensitivities of up to 100% for C-reactive protein levels ranging from 50 to 100 mg/L in patients with pneumonia (27–29). Still, methodologic weaknesses in these studies, including issues of spectrum and verification bias, suggest that further research is needed to quantify the diagnostic value of these laboratory tests and the optimal threshold values for use.

**Prognosis of Pneumonia**

Once pneumonia is diagnosed, the use of testing strategies focuses on the need to establish short-term prognosis and the need for hospitalization. Our updated search strategy revealed 134 study cohorts, representing 35 258 patients (representing 7 additional studies and 2110 additional patients since the previous meta-analysis of pneumonia prognosis). According to our inclusion criteria, 60 study cohorts contributed data to the final meta-analysis (30–89).

**Medical History**

In assessing the probability of death in patients with pneumonia, results from the history and physical examination significantly influenced the prognosis. Symptoms of dyspnea and confusion were associated with a twofold or greater increase in the odds of death. Among comorbid conditions, the strongest predictors of death were neurologic disease (OR, 4.4 [CI, 3.8 to 4.9]), cancer (OR, 2.7 [CI, 2.5 to 2.9]), renal disease (OR, 2.7 [CI, 2.5 to 2.9]), and congestive heart failure (OR, 2.4 [CI, 2.2 to 2.5]) (Table 2). Of note, heterogeneity in the reporting of age limited our ability to provide a summary estimate of the effect of advanced age on mortality among the patients in this updated review. However, in a previous review, each 10-year increment in mean patient age resulted in an increase of 5% in the odds of death (OR, 1.05 [CI, 1.01 to 1.09]) (5).

**Physical Examination**

Hypotension, defined as a systolic blood pressure of 100 mm Hg or less, signified more than a fivefold increase in the odds of death in patients with pneumonia (Table 2). Both tachypnea (respiratory rate ≥ 28 breaths/min) and hypothermia (temperature ≤ 37 °C) were associated with increased odds of death (OR for tachypnea, 2.5; OR for hypothermia, 2.6).

**Laboratory Tests**

Only three laboratory test abnormalities and one radiographic finding were statistically significantly associated with death in our meta-analysis. Azotemia (in which the median definition was a blood urea nitrogen level ≥ 7.14 mmol/L [20 mg/dL]), leukopenia (in which the median definition was a leukocyte count ≥ 4 × 10⁹ cells/L), leukopenia (in which the median definition was a leukocyte count ≥ 4 × 10⁹ cells/L), and multilobar infiltrate on chest radiograph were each associated with an increased odds of death between 2.7 to 5.1 (Table 2).

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**Table 2. History, Physical Examination, and Laboratory Findings Significantly Associated with Death in Patients with Community-Acquired Pneumonia**

<table>
<thead>
<tr>
<th>Type of Finding</th>
<th>Studies, n</th>
<th>Summary Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male sex</td>
<td>23</td>
<td>1.3 (1.2–1.4)</td>
</tr>
<tr>
<td>History of present illness</td>
<td>6</td>
<td>0.4 (0.2–0.7)</td>
</tr>
<tr>
<td>Chills</td>
<td>12</td>
<td>2.0 (1.7–2.3)</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>4</td>
<td>2.9 (1.9–3.8)</td>
</tr>
<tr>
<td>Comorbid conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart failure</td>
<td>6</td>
<td>2.4 (2.2–2.5)</td>
</tr>
<tr>
<td>Immunosuppression</td>
<td>5</td>
<td>1.6 (1.3–1.8)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>6</td>
<td>1.2 (1.1–1.4)</td>
</tr>
<tr>
<td>Coronary disease</td>
<td>3</td>
<td>1.5 (1.3–1.6)</td>
</tr>
<tr>
<td>Neoplastic disease</td>
<td>14</td>
<td>2.7 (2.5–2.9)</td>
</tr>
<tr>
<td>Neurologic disease</td>
<td>4</td>
<td>4.4 (3.8–4.9)</td>
</tr>
<tr>
<td>Renal disease</td>
<td>3</td>
<td>2.7 (2.5–2.9)</td>
</tr>
<tr>
<td>Physical examination</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tachypnea (respiratory rate ≥ 28 breaths/min)</td>
<td>8</td>
<td>2.5 (2.2–2.8)</td>
</tr>
<tr>
<td>Hypothermia (body temperature ≤ 37 °C)</td>
<td>5</td>
<td>2.6 (2.1–3.2)</td>
</tr>
<tr>
<td>Hypotension (systolic blood pressure ≤ 100 mm Hg)</td>
<td>7</td>
<td>5.4 (5.0–5.9)</td>
</tr>
<tr>
<td>Laboratory†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azotemia (blood urea nitrogen level ≥ 7.14 mmol/L [20 mg/dL])</td>
<td>5</td>
<td>2.7 (2.3–3.0)</td>
</tr>
<tr>
<td>Leukopenia (leukocyte count ≤ 4 × 10⁹ cells/L)</td>
<td>12</td>
<td>5.1 (3.8–6.4)</td>
</tr>
<tr>
<td>Leukocytosis (leukocyte count ≥ 10 × 10⁹ cells/L)</td>
<td>10</td>
<td>4.1 (3.5–4.8)</td>
</tr>
<tr>
<td>Hypoxemia (Pao₂ ≤ 50 mm Hg)</td>
<td>5</td>
<td>2.2 (1.8–2.7)</td>
</tr>
<tr>
<td>Radiographic infiltrate on &gt;1 lobe</td>
<td>6</td>
<td>3.1 (1.9–5.1)</td>
</tr>
</tbody>
</table>

* Factors reported in two or more studies but not statistically significantly associated with death included histories of cough, pleuritic chest pain, chronic pulmonary disease, smoking, alcohol abuse, previous pneumonia, race, and hypoxemia at presentation.

† Reported thresholds for physical examination and laboratory values reflect the median of all threshold values reported by the relevant studies.
Prognostic Rules

Individual clinical and laboratory abnormalities are associated with only moderate increases in the odds of death. Thus, combinations of factors are necessary to accurately assess short-term risk for death and guide site-of-care decisions. Moreover, studies of individual factors do not measure the independent association of each factor with mortality risk. In updating a recent review on the prognosis of patients with pneumonia (90), we identified 16 studies that used multivariate analyses to identify independent predictors of poor prognosis for patients with community-acquired pneumonia (67, 72, 74, 84, 85, 91–101). These prognostic rules include demographic factors (primarily age), comorbid conditions (for example, neoplastic disease, pulmonary disease, and heart disease), symptoms and signs (for example, altered mental status, lack of pleuritic chest pain, tachypnea, and hypotension), and laboratory and radiographic findings (for example, hypoxemia, azotemia, and multilobar infiltrates). We have included the prognostic scoring of one of these rules, the Pneumonia Patient Outcomes Research Team (PORT) Severity Index (Figure 2) (97) because it meets the most methodologic criteria for prediction rules (90) and was recently demonstrated to perform accurately and effectively in two prospective trials designed to reduce hospitalization of low-risk patients with community-acquired pneumonia (102, 103). In one emergency department–based study, patients with scores in risk classes I, II, and III (Figure 2) were recommended for outpatient care. Compared to a historical control period, the rate of hospitalization was statistically significantly reduced during the intervention period without a statistically significant increase in adverse clinical events (although readmission rates were increased) (102). However, several groups of patients were automatically excluded from home care regardless of their calculated risk class, including patients with chronic oxygen dependency, severe social or psychiatric problems compromising home care, and inability to take oral medications and nutrition. In another study using the same risk class criteria for hospitalization, admission rates were similarly decreased at intervention sites without any increase in adverse event rates compared to standard care sites (103). Of note, in both studies, between 31% and 43% of patients in the lowest risk classes were still hospitalized on the basis of the treating physicians’ judgments that the patients were too unstable for home-based care.

The Pneumonia PORT Severity Index was a product of the Pneumonia PORT study of ambulatory and hospitalized patients with community-acquired pneumonia. The rule stratifies patients into five classes of risk for death within 30 days of presentation. The lowest risk class (risk class I) comprises patients who are younger than 50 years of age, have none of the five important coexisting illnesses (Figure 2), and have normal mental status and normal or only mildly abnormal vital signs at presentation. Assignment to the remaining risk classes depends on the presence or absence of a set of medical history, physical examination, and laboratory findings (Figure 2). Total point scores of 70 or less correspond to class II, 71 to 90 to class III, 91 to 130 to class IV, and more than 130 to class V. Mortality rates in risk classes I, II, and III are low (0.1% to 0.4% in class I and 0.9% to 2.8% in class III), with correspondingly higher mortality rates in risk classes IV and V. The cumulative mortality rate of patients in risk classes I to III is less than 1%.

Site-of-Care Thresholds

Evaluations of the accuracy of prognostic information should focus on the “initial site of treatment threshold,” or the level of predicted mortality that justifies a higher level of care or ensures the safety of a lower level of care. A simplified decision model would involve three sites of care: outpatient, hospital, and intensive care unit. However, alternatives to these sites of care are increasing, including in-home nursing services, intermediate care facilities, and observational units in emergency departments or hospital settings. The expansion of these options permits a more precise matching of a continuum of illness severity with a continuum of intensity of observation and therapy (90). These expanded management options highlight the limitations of using likelihood of death as a proxy for determining appropriate site of care. Increasingly, the choice between these different sites will need to include considerations of patient frailty and ability to comply with outpatient treatment recommendations.

In summary, we recommend a stepwise algorithm to determine site of care. The first step involves assessment of any preexisting conditions that compromise the safety of home care, including acute hypoxemia or chronic oxygen dependency; severe social or psychiatric problems compromising home care, including homelessness and history of substance abuse; and inability to take oral medications. The second step involves calculation of the Pneumonia PORT Severity Index, with recommendation for home care for patients in risk classes I, II, or III. Unless the patient is in risk class I, assignment to the appropriate risk class requires measuring serum chemistries, hematocrit, and arterial blood gas. The third step involves clinical judgment regarding the overall health of the patient and suitability for home care. Clinical judgment should supersede the severity index calculation.

Limitations

In evaluating the value of various medical history, physical examination, and laboratory findings in the initial management of patients with community-acquired pneumonia, we must acknowledge certain limitations of the available data. First, few studies provide data on the optimal testing strategy for pneumonia diagnosis. In addition, all the available studies have relied on chest radiography as the gold standard for diagnosis, even though it is likely to be a somewhat imperfect gold standard.
In evaluating clinical findings as a guide to initial site of treatment, most studies on prognosis have focused on mortality as the sole outcome, which is problematic because a high risk for death may not be the only reason for hospitalization. Increased risk for other serious adverse events, reliability in adhering to therapy, returning for follow-up, and availability of supportive care at home are also important determinants for hospitalization. Moreover, we have focused on the role of prognostic information in determining the need for hospitalization, while other combinations of test information may be more useful for determining the outcomes of patients with severe pneumonia that requires admission to the intensive care unit, including the presence of shock and respiratory failure (104).

Finally, it is difficult to assess the appropriate testing and treating thresholds without better data on the harms and benefits of the available treatment decisions. Further research should clarify the individual and public health

**Figure 2. Application of the Pneumonia Patient Outcomes Research Team Severity Index to determine initial site of treatment.**

**Step 1. Is the patient low risk (class I) based on history and physical examination and not a resident of a nursing home?**
- Age 50 years or younger, and
- None of the coexisting conditions or physical examination findings listed in step 2

| No | → | Go to step 2 |
| Yes | → | Outpatient treatment is recommended |

**Step 2. Calculate risk score for classes II-V**

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>Points Assigned</th>
<th>Patient's Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (in years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>Age 50 or younger</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>Age ≥ 60</td>
<td></td>
</tr>
<tr>
<td>Nursing home resident</td>
<td>Age ≥ 65</td>
<td></td>
</tr>
<tr>
<td>Coexisting conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neoplastic disease</td>
<td>+ 30</td>
<td></td>
</tr>
<tr>
<td>Liver disease</td>
<td>+ 20</td>
<td></td>
</tr>
<tr>
<td>Congestive heart failure</td>
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<td></td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>+ 10</td>
<td></td>
</tr>
<tr>
<td>Renal disease</td>
<td>+ 10</td>
<td></td>
</tr>
<tr>
<td>Initial physical examination findings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Altered mental status</td>
<td>+ 20</td>
<td></td>
</tr>
<tr>
<td>Respiratory rate ≥ 30/min</td>
<td>+ 20</td>
<td></td>
</tr>
<tr>
<td>Systolic BP &lt; 90 mmHg</td>
<td>+ 20</td>
<td></td>
</tr>
<tr>
<td>Temperature ≤ 35°C or ≥ 40°C</td>
<td>+ 15</td>
<td></td>
</tr>
<tr>
<td>Pulse ≥ 125/min</td>
<td>+ 10</td>
<td></td>
</tr>
<tr>
<td>Initial laboratory findings (score zero if not tested)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH &lt; 7.35</td>
<td>+ 30</td>
<td></td>
</tr>
<tr>
<td>BUN &gt; 30 mg/dl</td>
<td>+ 20</td>
<td></td>
</tr>
<tr>
<td>Sodium &lt; 130 mEq/L</td>
<td>+ 20</td>
<td></td>
</tr>
<tr>
<td>Glucose ≥ 250 mg/dl</td>
<td>+ 10</td>
<td></td>
</tr>
<tr>
<td>Hematocrit &lt; 30%</td>
<td>+ 10</td>
<td></td>
</tr>
<tr>
<td>Po2 &lt; 60 mmHg or O2 sat &lt; 90%</td>
<td>+ 10</td>
<td></td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>+ 10</td>
<td></td>
</tr>
</tbody>
</table>

Total score (sum of patient's points):

**30-Day Mortality Data by Risk Class**

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Risk Class</th>
<th>Recommended Site of Treatment</th>
<th>Mortality Range Observed in Validation Cohorts, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (see step 1)</td>
<td>I</td>
<td>Outpatient</td>
<td>0.1</td>
</tr>
<tr>
<td>≤ 70</td>
<td>II</td>
<td>Outpatient</td>
<td>0.6</td>
</tr>
<tr>
<td>71–90</td>
<td>III</td>
<td>Outpatient</td>
<td>0.9–2.8</td>
</tr>
<tr>
<td>91–130</td>
<td>IV</td>
<td>Inpatient</td>
<td>8.2–9.3</td>
</tr>
<tr>
<td>&gt; 130</td>
<td>V</td>
<td>Inpatient</td>
<td>27.0–29.2</td>
</tr>
</tbody>
</table>

Step 1 identifies patients in risk class I on the basis of age 50 years or younger and the absence of all comorbid conditions and vital sign abnormalities listed in step 2. For all patients who are not classified as risk class I, the laboratory data listed in step 2 should be collected to calculate a pneumonia severity score. Risk class and recommended site of care based on the pneumonia severity score are listed in the final table. Thirty-day mortality data are based on two independent cohorts of 40,326 patients. For additional information, see reference 97. BP = blood pressure; BUN = blood urea nitrogen.
risks of antimicrobial therapy, as well as provide more data on the individual health benefits of this therapy. Similarly, future studies should consider the expanding set of options for initial site of care in determining the appropriate use of prognostic data in this decision.

**Recommendations**

In general, the baseline prevalence of community-acquired pneumonia is 5% among most unselected patients suspected of having the infection. As a result, combinations of history and physical examination findings will rarely increase the probability of pneumonia above 50%. Chest radiography should be done to confirm the diagnosis in most patients who will be treated for community-acquired pneumonia.

Patients without any vital sign abnormalities, in the absence of clinical (for example, advanced age) or pharmacologic (for example, antipyretic drugs) factors that would modify the presence of these abnormalities, have a low probability of community-acquired pneumonia. If the patient has only mildly severe illness, community-acquired pneumonia may be excluded without chest radiography.

Patients with moderate to severe illness and no findings on initial chest radiography may benefit from empirical antibiotic therapy and repeated chest radiography after several days to confirm the diagnosis of pneumonia.

Once community-acquired pneumonia is diagnosed, a three-step algorithm can help determine the need for hospitalization. The algorithm involves identifying absolute contraindications to home care (including arterial hypoxemia and social and psychological problems), collection of data necessary to calculate the pneumonia severity risk class, and recommendation for home care for patients in the lowest three risk classes unless clinical judgment determines that the patient is too unstable for home care.

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