Prospective evaluation of pneumonia severity index in hospitalised patients with community-acquired pneumonia

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Summary The aim of the present study was to investigate whether the pneumonia severity index (PSI) could adequately predict the severity of community-acquired pneumonia (CAP) and could be used as a severity of illness classification system. Furthermore, reasons that may influence the decision to admit low risk patients were analysed.

In a prospective study 260 patients with CAP were included. Stratification in five risk classes according to the PSI was compared with parameters that are closely related to severity of CAP. A significant difference in severity parameters, such as length of stay (P < 0.001) and simplified acute physiologic score and acute physiologic and chronic health evaluation II score (P < 0.001) was found between the five risk classes. Furthermore, a positive British Thoracic Society (BTS) rule and modified BTS rule score was significantly more prevalent in the higher risk classes (P < 0.001). The patient population had an average 30-day mortality of 10% and a mean Intensive Care Unit (ICU) admission rate of 8%. The mortality rate and ICU admission rate significantly differed between the five risk classes (P < 0.001), in which the highest ICU admission rate (40.9%) and the highest mortality percentage (40.9%) were both found in risk class V.

Several clinical factors (n = 64), such as an exacerbation of chronic obstructive pulmonary disease in 17 patients and clinical appearance of being ill in 16 patients, lack of improvement on outpatient antibiotic therapy (n = 15) and social circumstances (n = 3) were reasons that influenced the decision to hospitalise low risk patients (n = 82).

The results show that the PSI adequately predicted the severity of CAP and can be used as a severity of illness classification in CAP. Clinical and social factors other than...
Introduction

Most patients with community-acquired pneumonia (CAP) are treated as outpatients, but many low risk patients who could actually be treated at home are still hospitalised. The reason arises from the tendency of physicians to overestimate the risk of complications in CAP. In 1997 Fine et al. developed a pneumonia severity index (PSI) by which low risk patients with CAP can be identified. The reason for developing such a PSI was to enable the physician to make an objective assessment of the risk of mortality and to improve the decision about hospitalisation.

The PSI stratifies patients with CAP according to a two-step model, based on variables as age, sex, comorbid illness, vital sign abnormalities, and some laboratory and radiographic abnormalities, into five risk classes. Patients stratified in classes I and II have a low risk of mortality and can be safely treated at home. The PSI can be used as a tool additional to the clinical judgement of the physician. An important consequence of applying the PSI is a reduction in financial costs, using outpatient treatment in low risk patients with CAP, thereby resulting in a reduction of hospital admissions.

As a risk classification system the PSI has the potential, apart from identifying low risk patients, to be used as a tool in which processes of care and the outcome of different management strategies could be evaluated and compared with other studies. It was decided to assess prospectively whether the PSI could adequately stratify patients in the different risk classes when evaluating the severity of CAP in our health care system, and could therefore serve as a severity of illness classification system. Furthermore, reasons that may influence the decision to admit low risk patients (risk classes I and II) were analysed.

Methods

This prospective observational study was performed in the Departments of Pulmonary Diseases and Internal Medicine at the Medical Centre Alkmaar, a teaching hospital with 900 beds. Between December 1998 and November 2000, 303 hospitalised patients were included. As it is common in our health care system, the majority of patients first consult their general practitioner (GP), and from this population a selected group was referred to our hospital. Forty-three patients were initially misdiagnosed and were subsequently excluded from the study. The results from 260 patients could be evaluated.

Patients who fulfilled the following inclusion criteria for CAP were enrolled in the study after giving written informed consent: (1) age of at least 18 years old; (2) clinical presentation of an acute illness with two or more of the following symptoms suggesting CAP: presence of fever, dyspnoea, coughing (with or without expectoration of sputum), chest pain; (3) presence of a new consolidation on the chest radiograph. Patients were excluded from the study if one of the following criteria applied: presence of severe immunosuppression (HIV infection; high dose of immunosuppressive agents, like prednisone > 35 mg/day; chemotherapy); presence of malignancy; pregnancy or breastfeeding; documented severe allergy for antibiotics; presence of obstruction pneumonia; CAP presenting within 8 days after hospital discharge.

Patients were stratified into the five risk classes of the PSI according to the classification of Fine et al. The primary aim of this study was to assess whether the PSI could adequately predict severity of CAP and was therefore compared with length of hospital stay (LOS), duration of intravenous antibiotic treatment (ABiv), total duration of antibiotic therapy (ABtot), intensive care unit admission (ICU), 30-day mortality, simplified acute physiologic score (SAPS), acute physiologic and chronic health evaluation (APACHE) II score, positive British Thoracic Society (BTS) rule, positive modified British Thoracic Society (mBTS) rule and the results of the pneumonia patient outcomes research team (PORT) prospective cohort study. Reasons that influenced the decision to hospitalise patients stratified in classes I and II were analysed. These reasons were based on the personal judgement of the physician about the clinical or social situation of the patient at the moment of admission. The treating physician was not aware of the PSI risk class stratification.

All data necessary for calculating the PSI were prospectively collected at admission at day 1 by the investigator (MMvdE). SAPS score, APACHE II score,
**Statistical analysis**

Data were compared and analysed with one-way analysis of variance (ANOVA) with post hoc Bonferroni correction for continuous variables and with $\chi^2$ test for nominal data using SPSS Version 11.5. Data are expressed as means with standard deviation or as absolute number. A result of $P<0.05$ was considered to be significant.

**Results**

Demographic data from the 260 patients included in the study are presented in **Table 1**. The mean age was 64 years; 200 patients (77%) were aged $\geq$ 50 years. The male and female populations were almost equally distributed (54% versus 46%, respectively). Only 6 patients (2%) were admitted from nursing homes. The most common co-morbidity was chronic obstructive pulmonary disease (COPD), present in 103 patients (40%), followed by diabetes mellitus (10%), asthma (9%), and congestive heart failure (8%).

**Table 2** details the assignment of patients into the five risk classes. Ninety-two patients (35%) with CAP were assigned to class IV, followed by 64 patients (25%) stratified in class III and 59 patients (23%) in class II. Patients assigned to a lower risk class were generally younger than patients classified in a higher risk class.

A significant difference in LOS was seen between the five different risk classes ($P<0.001$). Patients stratified in class V remained in the hospital for the longest period, with a mean stay of 19.9 days. A difference between the risk classes was also seen in duration of ABiv ($P=0.007$), while no significant difference was found in length of ABtot ($P=0.14$).

The PSI was compared with APACHE II score and SAPS score. The scores obtained from these two general predicting scoring systems increased significantly with the stratification in the five risk classes ($P<0.001$) (**Table 3**). However, no significant difference in APACHE II and SAPS score was seen between risk classes IV and V.

A positive BTS and mBTS score was significantly more prevalent in the higher risk classes. In contrast to the APACHE II and SAPS score, a significant difference in positive BTS and positive mBTS score was present between patients stratified into risk class IV or V ($P<0.001$).

The patient population had an average 30-day mortality of 10% and a mean ICU admission rate of 8%. The highest ICU admission rate (40.9%) and the highest mortality percentage (40.9%) were both found in risk class V. The mortality rate and ICU admission rate significantly differed between the five risk classes ($P<0.001$). Regarding the prediction of mortality in the present study population, stratification in risk class V showed a sensitivity of

<table>
<thead>
<tr>
<th>Variables</th>
<th>Number (%)</th>
</tr>
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<tbody>
<tr>
<td>Mean age, years ($\pm$ SEM)</td>
<td>64 (1.1)</td>
</tr>
<tr>
<td>$\leq$50 years</td>
<td>60 (23%)</td>
</tr>
<tr>
<td>$&gt;$50 years</td>
<td>200 (77%)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>140 (54%)</td>
</tr>
<tr>
<td>Female</td>
<td>120 (46%)</td>
</tr>
<tr>
<td>Nursing home residents</td>
<td>6 (2%)</td>
</tr>
<tr>
<td>Comorbidity</td>
<td></td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>103 (40%)</td>
</tr>
<tr>
<td>Asthma</td>
<td>23 (9%)</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>20 (8%)</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>17 (7%)</td>
</tr>
<tr>
<td>Cerebrovascular accident</td>
<td>4 (2%)</td>
</tr>
<tr>
<td>Other neurologic disorder</td>
<td>20 (8%)</td>
</tr>
<tr>
<td>Liver disease</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>Renal disease</td>
<td>2 (1%)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>25 (10%)</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
</tr>
<tr>
<td>Smoker ($\geq$10 cigarettes/day)</td>
<td>74 (28%)</td>
</tr>
<tr>
<td>Smoker ($&lt;$10 cigarettes/day)</td>
<td>9 (3%)</td>
</tr>
<tr>
<td>Ex-smoker</td>
<td>79 (30%)</td>
</tr>
<tr>
<td>Non-smoker</td>
<td>87 (33%)</td>
</tr>
<tr>
<td>Alcohol</td>
<td></td>
</tr>
<tr>
<td>Drinker ($&gt;$3 units/day)</td>
<td>12 (5%)</td>
</tr>
<tr>
<td>Non-drinker</td>
<td>232 (89%)</td>
</tr>
</tbody>
</table>
33%, a specificity of 94%, a positive predictive value of 41% and a negative predictive value of 92% (data not shown).

Table 4 shows the reasons for admission of the 23 patients (9%) of class I and of the 59 patients (23%) of class II. The reasons for admission (in order of prevalence) were: acute chest pain in 30 patients (37%) (in most cases the presence of a suspected pulmonary embolism needed to be excluded); an exacerbation of COPD in 17 patients (21%); clinical appearance of being ill in 16 patients (20%); no improvement on oral outpatient antibiotic therapy in 15 patients (18%) and hypoxemia in 1 patient (1%). Three patients (4%) could have been treated at home, but preferred treatment in a hospital for social reasons.
Age is a very important variable in the PSI. According to the two-step model patients $> 50$ years can directly be placed in risk classes II–V. Seven patients (3%) aged $\leq 50$ years old were hospitalised because of a clinical appearance of being ill, although they did not score enough points for stratification in a higher risk classes (class III–V). Two of these patients—besides having clinical signs of severe CAP—were suspected of having meningitis. With radiological imaging the diagnosis of lung abscesses was confirmed in two patients, and a prolonged course of intravenous antibiotics was prescribed. At presentation three other patients displayed a combination of symptoms, which made hospitalisation necessary.

In some studies low risk patients are defined as patients stratified in risk classes I to III. Three patients (4.7%) stratified in risk class III died; two of them had a Legionella pneumophila infection. In the other patient no pathogen could be identified. All three patients showed a positive mBTS score. In risk class II one patient died because of the presence of multi-organ failure caused by pneumonia and confirmed meningitis.

Discussion

The present study showed that the PSI could predict severity of CAP adequately. When predicting mortality and ICU admission, the PSI adequately stratified patients with CAP in the five different risk classes. The highest ICU admission and mortality rates were found in risk classes IV and V. This is in accordance with the results of the PORT study and the results published by Ewig et al. and Roson et al. APACHE II, SAPS, positive BTS and mBTS score showed increasing trends across all 5 risk classes. No difference between the risk classes was seen in the total duration of antibiotic use, reflecting the general opinion of treating CAP with a course of antibiotics during 7–10 days, irrespective of the severity of CAP. Acute chest pain, exacerbation of chronic obstructive pulmonary disease, clinical judgement overruling the PSI, lack of improvement on oral outpatient antibiotic therapy and social circumstances were reasons that influenced the decision to hospitalise low risk patients.

The PSI was originally developed to identify low risk patients with CAP, based on risk of death within 30 days. Validation of the prediction rule was performed with data from a database of 38,000 patients and with data from the PORT study. The primary aim of our study was to determine whether the PSI could also serve as a specific severity of illness classification system for CAP. Therefore, we validated the PSI with several other severity outcome parameters besides risk of death. We consider that the use of the PSI as a severity of illness classification system is important, because the composition of a study population with CAP will become clearer. In this way processes of care and outcomes in management can be evaluated, furthermore different studies of CAP can be compared more precisely on their outcome. Our results together with the results of the PORT study and the results of the studies performed by Ewig et al. and Roson et al. suggest that the PSI can also be used as a specific severity of illness classification system for CAP. It can serve as a system to stratify patients into classes of comparable severity by analogy with the APACHE II and SAPS scoring systems.

According to the PSI the decision to hospitalise a patient with CAP is based only on the severity of CAP. In the present study five reasons were found that played an important role in the decision to admit the 82 patients (32%) stratified in classes I and II. These were: (a) acute chest pain; (b) the presence of COPD; (c) lack of improvement on oral outpatient antibiotic therapy; (d) clinical judgement overruling the PSI; (e) social circumstances. These factors are not mentioned in the PSI, but it is important to consider them when making the decision whether or not to hospitalise a patient with CAP. For example, the presence of COPD as co-morbidity in CAP is often considered to be an important risk factor leading to admission and mortality.

Another reason for hospital admission in this study was a lack of response to initial therapy started by a GP. This is also mentioned as a hospital admission criterion in a study performed by Menendez et al. and by the European Study on CAP Committee.

An important point that should also be taken into consideration when using the PSI is the variable of age. In this scoring system age has a major influence on risk class stratification, because of the high amount of points assigned to it. In the present study a number of young patients who had the appearance of being very ill, and for whom hospitalisation was necessary, were stratified in a low risk class. The clinical judgement of the treating physician in these cases overruled the predictive value of the PSI. The major influence of age in the PSI is also brought to attention in the current guidelines of the American Thoracic Society.
Marras et al. also investigated reasons for the admission of low risk patients. Comorbid illness, failure of outpatient antibiotic therapy and social circumstances were mentioned as reasons for hospitalisation. Although this was a retrospective study these results were very similar to the outcomes of this present prospective study. Another study assessed whether applying the PSI could safely increase the proportion of low risk patients treated at home. Of the 166 identified low risk patients, only 94 (57%) were treated as outpatients and 72 (43%) were admitted. In a later study the reasons for admission of this patient group were described (18). Predictors for hospital admission, after multivariate analysis, were age >65 years, multilobar pneumonia and the presence of other comorbid conditions. Interestingly, the physicians’ self-reported reasons for admission were also described. The presence of other active comorbidities and the clinical judgment that the pneumonia was worse than the PSI score indicated influenced the decision to hospitalise a low risk patient. This observation underlines the fact that a considerable percentage of patients has to be admitted to the hospital for several reasons, despite stratification in a lower risk class.

In the present study we did not analyse reasons for admission of patients from risk class III. The Infectious Diseases Society of America recommends to treat patients from risk class III as outpatients or to observe them for a brief period in the hospital. The results showed a mortality percentage of 4.7 (n = 3) in this patient category, compared to a predicted mortality <1% in the PORT study. Interestingly all 3 patients had a positive mBTS score.

When interpreting the results one has to realise that the Health Care system in the Netherlands is different from other countries, like for example the USA, which may influence the sort of study population referred to the hospital. As is mentioned in the methods section many patients in our country initially visit the GP. When necessary, the GP subsequently refers patients to the hospital. The presence of comorbidity (50% in our study) and the severity of disease are in this context important. When making this decision, the GP does not have the opportunity of obtaining the laboratory values needed in the PSI. The decision to hospitalise is therefore based on clinical judgement. However, there is clearly need for a simple tool to make this decision more objective. This applies especially to the first step of the PSI, in the form of information about age, co-morbidity and abnormal vital signs. But this information only is insufficient for stratification in classes III, IV and V, which require the availability of laboratory tests and a chest X-ray. Under these circumstances the PSI does not seem to be an adequate instrument for the GP in the Netherlands to use. Whether the PSI should be adapted for this situation could be an area for future research.

In conclusion, the PSI adequately stratified patients in the different risk classes according to severity of CAP and therefore can be used as a severity of illness classification for CAP. This has important consequences for evaluating processes of care and outcomes of therapy in patients with CAP. The present study has also demonstrated that the decision to hospitalise patients with CAP cannot be based purely on the severity of CAP according to the PSI. Various reasons could influence this decision. In our opinion the variable of age counts too heavily in the scoring of the PSI. As a consequence some young patients with severe CAP will not be stratified in a higher risk class, which is necessary for being admitted. Further research is needed to optimise an adequate tool for the physician who has to make the difficult decision about admitting patients with CAP.

Acknowledgements

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References


