C-Reactive Protein Is an Independent Predictor of Severity in Community-acquired Pneumonia

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ABSTRACT

BACKGROUND: C-reactive protein (CRP) is an acute phase protein synthesized by the liver primarily in response to interleukin-6. Initial studies have suggested that inflammatory markers may have a role in predicting severity. We investigated whether admission and day 4 CRP could predict severity in community-acquired pneumonia.

METHODS: A prospective study was carried out over a 2-year period in a large teaching hospital. CRP was measured on admission and on day 4. The outcomes of interest were: 30-day mortality; need for mechanical ventilation and/or inotropic support; development of complicated pneumonia (lung abscess, empyema, or complicated parapneumonic effusion); the value of predictive tests were assessed using multivariate logistic regression.

RESULTS: There were 570 patients included in the study; 30-day mortality was 9.6%. Low CRP levels showed a high negative predictive value for excluding 30-day mortality (CRP ≤ 10 mg/L = 100%, CRP ≤ 50 = 99.1%, CRP ≤ 100 = 98.9%, CRP ≤ 200 = 94.9%). Low admission CRP levels < 100 mg/L were independently associated with reduced 30-day mortality (odds ratio [OR] 0.18; 0.04-0.85), P = .03; need for mechanical ventilation and/or inotropic support (OR 0.21; 0.14-0.4), P = .002; and complicated pneumonia (OR 0.05; 0.01-0.35), P = .003. A CRP that fails to fall by 50% or more within 4 days of admission is independently associated with increased 30 day mortality (OR 24.5; 6.4-93.4), P < .0001; need for mechanical ventilation and/or inotropic support (OR 7.1; 2.8-17.8), P < .0001 and complicated pneumonia (OR 15.4; 6.3-37.6), P < .0001.

CONCLUSIONS: Admission CRP < 100 mg/L has reduced risk for 30-day mortality, need for mechanical ventilation and/or inotropic support, and complicated pneumonia. Failure of CRP to fall by 50% or more at day 4 leads to an increased risk for 30-day mortality, need for mechanical ventilation and/or inotropic support, and complicated pneumonia. C-reactive protein is an independent marker of severity in community-acquired pneumonia.

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KEYWORDS: Community-acquired pneumonia; C-reactive protein; Severity assessment

The initial clinical decision to admit or discharge a patient with community-acquired pneumonia can be difficult. Data from the United States show the estimated average cost of inpatient care for community-acquired pneumonia is $7500, compared with $150-$350 for outpatient care.1 Evidence suggests that in many cases physicians overestimate the severity of community-acquired pneumonia, leading to unnecessary admissions, whereas others suggest that initial assessment may underestimate the potential severity of community-acquired pneumonia.2 This has led to the development of a number of severity scores and prediction rules. In the UK, the CURB65 prediction score has been in use since 20043 and is aimed to identify high-risk patients at risk of death and prioritize these patients for aggressive investigation, treatment, and care in High Dependency or Intensive Care environments, where appropriate. The Pneumonia Severity Index is used in the US and classifies patients into 5 risk classes based on a number of clinical, demographic, laboratory, and radiological findings that predict 30-day mortality.4

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C-reactive protein (CRP) is an acute phase protein produced primarily in the liver and is stimulated by cytokine release, primarily interleukin-6. Small studies suggest that an elevated CRP is relatively nonspecific and is not directly related to severity. On the basis of this evidence, the 2004 update of the British Thoracic Society (BTS) guidelines does not recommend admission CRP as a marker of severity. However, the guidelines recommend measurement of CRP as a useful marker of treatment failure in community-acquired pneumonia. A CRP that fails to fall by 50% or more within 4 days of admission is indicative of adverse outcomes such as empyema. It is well recognized that elevated concentrations of proinflammatory cytokines correlate with severity and outcome of sepsis, and it has been shown that elevated CRP is an independent predictor of mortality in acutely ill patients. This has not been specifically examined in community-acquired pneumonia. No previous studies have examined whether a low CRP can exclude severe community-acquired pneumonia.

The aim of this study was to establish if admission and day 4 CRP can predict 30-day mortality, need for mechanical ventilation and/or inotropic support, and the development of complicated pneumonia.

METHODS

We conducted a prospective study of all adult patients admitted between February 2005 and February 2007 with a primary diagnosis of community-acquired pneumonia. Ethical approval was obtained from the Lothian research ethics committee.

The main inclusion criteria were presentation to hospital with a diagnosis of community-acquired pneumonia within the study period (February 2005 to February 2007) and the absence of any exclusion criteria. Community-acquired pneumonia was defined as a history consistent with pneumonia (with 1 or more of the following: new-onset shortness of breath, cough, sputum production, haemoptysis, chest pain, new-onset confusion, or pyrexia) and new infiltrates on the chest radiograph.

In addition, the authors reviewed patient records at follow-up clinic review to ensure that the discharge diagnosis was considered to be pneumonia and that no exclusion criteria were present. Exclusion criteria are shown in Table 1.

### Site of Care and Data Collection

The Royal Infirmary of Edinburgh is a large teaching hospital serving Lothian and the South East of Scotland, UK with 900 inpatient beds. Patients present either as self-referral to Accident and Emergency or via General Practitioner referral to the Medical Assessment unit. At both sites, patients are reviewed by the medical team and the decision to admit or discharge the patient is made. A proforma is completed on admission that includes patient observations (blood pressure, pulse, respiratory rate, temperature), and standard blood tests are obtained for each patient (full blood count, urea and electrolytes, liver function tests, coagulation profile, and CRP). C-reactive protein was mea-
sured on admission in all patients and repeated routinely at day 4. C-reactive protein was repeated at other times as clinically indicated.

Subsequently, patients spend 12-24 hours in the Combined Assessment Unit, from where they may be discharged or move on to a specialist ward. Critically ill patients may be admitted at any time to the Intensive Care Unit for invasive ventilation and/or inotropic support or to the high dependency unit, which provides intensive monitoring as well as noninvasive ventilation (bilevel or continuous positive airways pressure ventilation) and/or inotropic support.

Patients were enrolled in the study from both Accident and Emergency and the Medical Assessment unit. Data were obtained from patients’ case notes and from the hospital laboratory database. Clinical observations were taken from the admission pro-forma. All observations were taken in the Emergency Department within 4 hours of arrival.

All patients received standard antibiotic therapy in accordance with British Thoracic Society guidelines.7

C-Reactive Protein Measurement

C-reactive protein was measured by fluorescence polarization immunoassay using an Abbott TDX analyzer and Abbott reagents (Abbott Laboratories, Abbott Park, Ill). This CRP assay is a standard assay used in British hospitals. The CRP assay reports results in mg/L. The normal range for this assay is $<10$ mg/L. Other studies examining CRP have used assays that report in mg/dL. For purposes of comparison, a C-reactive protein level of 100 mg/L is equivalent to 10 mg/dL.

Outcomes

The primary outcome of interest was 30-day mortality. Secondary outcomes were need for mechanical ventilation and/or inotropic support and development of complicated pneumonia (lung abscess, empyema, or complicated parapneumonic effusion).

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### Table 2: Patients Excluded from Study

<table>
<thead>
<tr>
<th>Reason for Exclusion</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital acquired pneumonia</td>
<td>31</td>
</tr>
<tr>
<td>Active malignancy</td>
<td>54</td>
</tr>
<tr>
<td>Immunosuppression</td>
<td>29</td>
</tr>
<tr>
<td>Solid organ transplant</td>
<td>2</td>
</tr>
<tr>
<td>Chronic liver disease</td>
<td>6</td>
</tr>
<tr>
<td>Persistent shadowing on chest radiograph at follow-up</td>
<td>49</td>
</tr>
<tr>
<td>Active treatment not appropriate</td>
<td>18</td>
</tr>
<tr>
<td>Diagnosis other than pneumonia made at follow-up</td>
<td>20</td>
</tr>
<tr>
<td>Diagnosis of lung cancer at follow-up</td>
<td>33</td>
</tr>
<tr>
<td>Chronic lung disease</td>
<td>124</td>
</tr>
</tbody>
</table>

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**Statistical Analysis**

All data were analyzed using SPSS version 13 for Windows (SPSS Inc., Chicago, Ill). Descriptive statistics of demographic and clinical variables are presented as median (interquartile range) unless otherwise stated. The Mann-Whitney U test was used for the comparison of 2 groups of continuous data. Sensitivity, specificity, negative predictive value, positive predictive value, and the area under the receiver operator characteristic (ROC) curve was use for comparison of predictive tests. A $2 \times 2$ table using the Fisher’s exact test was used to compare readmissions before day 4. For all analyses, a 2-tailed $P$ value of $<.05$ was considered statistically significant.

We used multiple logistic regression to compare the outcomes of interest in patients with elevated CRP (≥100 mg/L) compared with patients with lower CRP levels (<100 mg/L). To the baseline model we included age, sex, pneumonia severity (using CURB65 score), co-morbidity (chronic cardiac failure, stroke, chronic renal failure, diabetes mellitus), and smoking status. Age was entered into the model as a continuous variable, whereas other variables were coded as binary data.

**RESULTS**

There were 936 patients considered for inclusion during the study period; 570 patients met the criteria and were included in the study. Reasons for exclusion are shown in Table 2.

Baseline characteristics of the study population are shown in Table 3. Characteristics are shown for the whole population and for those patients who had repeat C-reactive protein measurements available during the first 4 days of treatment.

Of all patients, 20.7% were discharged within 24 hours of admission; 13.5% required invasive ventilation and/or inotropic support. Complicated pneumonia developed in 7.3% of patients. The 30-day mortality rate was 9.6%.

### Table 3: Population Characteristics

<table>
<thead>
<tr>
<th>Baseline Characteristics</th>
<th>Study Population</th>
<th>Patients with Repeat CRP Measurement Up to Day 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>570</td>
<td>358</td>
</tr>
<tr>
<td>Age (years)</td>
<td>62 (44-76)</td>
<td>62 (44-77)</td>
</tr>
<tr>
<td>Sex - % male</td>
<td>48.8%</td>
<td>48%</td>
</tr>
<tr>
<td>Duration of admission (days)</td>
<td>5 (2-11)</td>
<td>6 (3-11)</td>
</tr>
<tr>
<td>Chronic cardiac disease</td>
<td>75 (13.2%)</td>
<td>49 (13.7%)</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>51 (8.9%)</td>
<td>35 (9.8%)</td>
</tr>
<tr>
<td>Chronic renal failure</td>
<td>25 (4.4%)</td>
<td>16 (4.4%)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>38 (6.6%)</td>
<td>18 (5%)</td>
</tr>
<tr>
<td>Current smokers</td>
<td>204 (36%)</td>
<td>121 (33.8%)</td>
</tr>
<tr>
<td>Exsmokers</td>
<td>145 (25%)</td>
<td>87 (24.3%)</td>
</tr>
<tr>
<td>Nonsmokers</td>
<td>221 (39%)</td>
<td>150 (41.9%)</td>
</tr>
</tbody>
</table>

**CRP** = C-reactive protein.

Definitions for co-morbid conditions were as used in previous studies.4 Data presented as median (interquartile range) or % number of patients.
similar to previous studies by Lim et al\textsuperscript{3} and Fine et al\textsuperscript{4} (Table 4).

### Admission C-Reactive Protein as a Predictor of 30-day Mortality, Need for Invasive Ventilation and/or Inotropic Support, and Complicated Pneumonia

Thirty-day mortality, need for invasive ventilation and/or inotropic support, and rates of complicated pneumonia increase with increasing levels of CRP on admission (Table 5).

On multivariate logistic regression, a CRP <100 mg/L was independently associated with a reduced risk of:

- 30-day mortality (odds ratio [OR] 0.18; 0.04-0.85; \( P = .03 \))
- Need for invasive ventilation and/or inotropic support (OR 0.21; 0.14-0.4; \( P = .002 \))
- Complicated pneumonia (OR 0.05; 0.01-0.35; \( P = .003 \))

### Predictive Value of C-Reactive Protein for Outcome in Community-acquired Pneumonia

C-reactive protein had high negative predictive values for excluding 30-day mortality up to levels <100 mg/L. The performance of CRP using a cut-off of 100 mg/L was compared with the existing severity criteria: CURB65\textsuperscript{3} and the Pneumonia Severity Index scores\textsuperscript{4} (Table 6).

C-reactive protein <100 mg/L showed comparable negative predictive values for excluding 30-day mortality, need for mechanical ventilation, and/or inotropic support and complicated pneumonia. The area under the ROC curve for CRP was lower for 30-day mortality and need for mechanical ventilation and/or inotropic support, but was higher for predicting complicated pneumonia.

### Admission CRP Combined with Day 4 CRP as a Predictor of Outcome

Repeat CRP measurements at day 4 were available in 268 patients (223 were discharged in <4 days, 26 died or were admitted to the Intensive Care Unit within 4 days with no repeat measurement available, and data were missing in 53 patients).

A C-reactive protein level that fails to fall by 50% or more within 4 days is associated with increased 30-day mortality, increased rates of mechanical ventilation and/or need for inotropic support, and a higher incidence of complicated pneumonia (Table 7).

On multivariate logistic regression, a CRP that failed to fall by 50% or more at day 4 was associated with increased:

- 30-day mortality (OR 24.5; 6.4-93.4; \( P < .0001 \))
- Need for invasive ventilation and/or inotropic support (OR 7.1; 2.8-17.8; \( P < .0001 \))
- Complicated pneumonia (OR 15.4; 6.32-37.6; \( P < .0001 \))

### C-Reactive Protein Measurement on Discharge Before Day 4

There were 223 patients discharged before day 4. There is no repeat C-reactive protein measurement available in 15 patients; 78% of patients had a discharge CRP <100 mg/L. There was only 1 readmission within 7 days in this group (0.6%) compared with 4 patients readmitted within 7 days in the CRP <100 mg/L group (8.7%, \( P = .009 \)).

### DISCUSSION

In this study, low CRP levels (<100 mg/L) have high negative predictive values in excluding 30-day mortality, requirement for invasive ventilation and/or inotropic support, and complicated pneumonia. In addition, repeat measurement of CRP at day 4 is shown to be a powerful marker

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### Table 4  Mortality and Existing Severity Scores (CURB65 and Pneumonia Severity Index)

<table>
<thead>
<tr>
<th>CURB65 Score</th>
<th>n</th>
<th>30-Day Mortality (All Patients)</th>
<th>National Studies (Lim et al)\textsuperscript{3}</th>
<th>PSI Class</th>
<th>n</th>
<th>30-Day Mortality (All Patients)</th>
<th>National Studies (Fine et al)\textsuperscript{4}</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>105</td>
<td>0%</td>
<td>0.7%</td>
<td>1</td>
<td>81</td>
<td>0%</td>
<td>0.1-0.4%</td>
</tr>
<tr>
<td>1</td>
<td>128</td>
<td>2.3%</td>
<td>3.2%</td>
<td>2</td>
<td>131</td>
<td>1.5%</td>
<td>0.6-0.7%</td>
</tr>
<tr>
<td>2</td>
<td>142</td>
<td>3.5%</td>
<td>3%</td>
<td>3</td>
<td>108</td>
<td>2.8%</td>
<td>0.9-2.8%</td>
</tr>
<tr>
<td>3</td>
<td>110</td>
<td>15%</td>
<td>17%</td>
<td>4</td>
<td>159</td>
<td>10.7%</td>
<td>4-10%</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>31%</td>
<td>41.5%</td>
<td>5</td>
<td>91</td>
<td>35.2%</td>
<td>27%</td>
</tr>
<tr>
<td>5</td>
<td>15</td>
<td>47%</td>
<td>57%</td>
<td>Total</td>
<td>570</td>
<td>9.6%</td>
<td>10.6%</td>
</tr>
</tbody>
</table>

| PSI = pneumonia severity index.  

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### Table 5  Admission C-Reactive Protein (CRP) and Adverse Outcomes

<table>
<thead>
<tr>
<th>C-Reactive Protein (mg/L)</th>
<th>n</th>
<th>30-Day Mortality (30-Day)</th>
<th>Invasive Ventilation and/or Inotropic Support</th>
<th>Complicated Pneumonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRP ≥400</td>
<td>70</td>
<td>18.8%</td>
<td>33.3%</td>
<td>21.7%</td>
</tr>
<tr>
<td>CRP 300-399</td>
<td>82</td>
<td>18.8%</td>
<td>20%</td>
<td>7.5%</td>
</tr>
<tr>
<td>CRP 200-299</td>
<td>106</td>
<td>9.6%</td>
<td>13.5%</td>
<td>15.4%</td>
</tr>
<tr>
<td>CRP 100-199</td>
<td>132</td>
<td>10.7%</td>
<td>15.2%</td>
<td>3.1%</td>
</tr>
<tr>
<td>CRP &lt;100</td>
<td>180</td>
<td>1.1%</td>
<td>2.2%</td>
<td>0.6%</td>
</tr>
<tr>
<td>CRP &lt;50</td>
<td>115</td>
<td>0.9%</td>
<td>0.9%</td>
<td>0%</td>
</tr>
<tr>
<td>CRP &lt;10</td>
<td>39</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
of treatment response—patients in whom the CRP level falls by 50% or more in 4 days have low rates of 30-day mortality, requirement for invasive ventilation and/or inotropic support, and development of complicated pneumonia. CRP may therefore be a useful adjunct to clinical judgement in identifying low-risk patients.

C-reactive protein is an acute phase protein synthesized by the liver in response to tissue damage. Interleukin-6 (IL-6) is thought to be the primary trigger of CRP release, although tumor necrosis factor (TNF)-alpha, IL-1, and other cytokines are thought to be involved. Studies of cytokines and inflammatory markers in community-acquired pneumonia have not translated into clinically useful tests, in part because TNF-alpha and interleukin-6 are detectable in only a minority of patients. Evidence of a relationship with severity has been conflicting, with some studies showing that TNF-alpha, IL-6, and soluble interleukin-2 receptor (IL-2R) do not correlate with severity. Others, however, have shown that IL-6 levels correlate with BTS severity score and that IL-6 and IL-10 (an anti-inflammatory cytokine) correlate with Apache II score and are higher in patients fitting the systemic inflammatory response syndrome criteria compared with patients who do not.16 TNF alpha, IL-6, and IL-1 beta levels appear also to be higher in patients admitted to the Intensive Care Unit with pneumonia compared with those with less severe pneumonia.17

As these cytokines are the primary stimulus for C-reactive protein release, it would seem to follow that CRP also should be higher in patients with severe pneumonia. Despite this, no large studies have examined CRP and mortality in community-acquired pneumonia. Studies have shown that elevated CRP in community-acquired pneumonia is independently associated with requirement for inpatient care, and that higher CRP levels result in longer duration of hospital stay and poorer clinical and radiological recovery. Elevated CRP also has been shown to be associated with increased mortality in lower respiratory tract infection in primary care.19

This is the first study of this size to examine whether CRP levels predict 30-day mortality in community-acquired pneumonia. Severity assessment is an important initial step in the management of community-acquired pneumonia.

### Table 6

<table>
<thead>
<tr>
<th>Prediction of 30-day mortality</th>
<th>PPV</th>
<th>NPV</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRP ≥100 mg/L</td>
<td>13.3%</td>
<td>98.9%</td>
<td>96.3%</td>
<td>34.5%</td>
<td>0.70 (0.66-0.74)</td>
</tr>
<tr>
<td>CURB65 score ≥3</td>
<td>23.6%</td>
<td>97.6%</td>
<td>85.2%</td>
<td>71.1%</td>
<td>0.83 (0.80-0.87)</td>
</tr>
<tr>
<td>Pneumonia Severity Index ≥3</td>
<td>14.5%</td>
<td>99.1%</td>
<td>96.3%</td>
<td>40.7%</td>
<td>0.83 (0.80-0.87)</td>
</tr>
</tbody>
</table>

### Table 7

<table>
<thead>
<tr>
<th>C-Reactive Protein (mg/L)</th>
<th>n</th>
<th>Day 4 CRP</th>
<th>Mortality (30 Days)</th>
<th>Invasive Ventilation/Inotropic Support</th>
<th>Complicated Pneumonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>570</td>
<td>n/a</td>
<td>9.6%</td>
<td>13.5%</td>
<td>7.3%</td>
</tr>
<tr>
<td>All patients</td>
<td>175</td>
<td>Decreased by ≥50%</td>
<td>0.5%</td>
<td>1.7%</td>
<td>2.3%</td>
</tr>
<tr>
<td>All patients</td>
<td>93</td>
<td>Increased/decreased by &lt;50%</td>
<td>18.3%*</td>
<td>22.6%*</td>
<td>19.4%*</td>
</tr>
<tr>
<td>CRP &lt;100</td>
<td>83</td>
<td>Decreased by ≥50%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>CRP &lt;100</td>
<td>13</td>
<td>Increased/decreased by &lt;50%</td>
<td>15.4%*</td>
<td>7.7%†</td>
<td>15.4%*</td>
</tr>
<tr>
<td>CRP ≥100</td>
<td>92</td>
<td>Decreased by ≥50%</td>
<td>1.1%</td>
<td>3.3%</td>
<td>4.3%</td>
</tr>
<tr>
<td>CRP ≥100</td>
<td>80</td>
<td>Increased/decreased by &lt;50%</td>
<td>18.8%*</td>
<td>26.3%*</td>
<td>20%*</td>
</tr>
</tbody>
</table>

Comparison between groups where CRP decreased by 50% or more compared with groups where CRP decreased by less than 50% or increased. n/a = not applicable.

*P < .001.
†P = .01.
difficulty of this initial assessment has led to development of a number of severity scores and indices to assist clinical decision-making. In the UK, the CURB65 score has become quickly established as an excellent tool for predicting patients at high risk of mortality. The CURB65 score was designed and is validated to predict 30-day mortality. It is not intended or validated to predict other outcomes, and studies suggest its performance is reduced when other outcome measures are considered.\textsuperscript{20}

In the present study, elevated CRP $\geq 100$ mg/L was associated not only with increased 30-day mortality, but also was a marker of requirement for invasive ventilation and/or inotropic support and development of complicated pneumonia. The high negative predictive value of CRP levels below 100 mg/L for each of these outcomes can reassure clinicians and has the potential to aid the initial decision to admit or discharge patients from hospital.

This study has shown that CRP $<100$ mg/L on admission has similar negative predictive values to the CURB65 and Pneumonia Severity Index scores for predicting 30-day mortality, need for mechanical ventilation and/or inotropic support, and the development of complicated pneumonia. The ROC curves demonstrate that CURB65 and Pneumonia Severity Index had superior performance for predicting 30-day mortality and need for mechanical ventilation and/or inotropic support. The area under the ROC curve for CRP appears to be reduced primarily due to its lower specificity at high levels of CRP ($\geq 200$ mg/L). The authors feel that the negative predictive value of a test is the most clinically relevant. C-reactive protein had, however, superior performance for predicting complicated pneumonia. The authors are not aware of any previous study that examined the predictive value of CURB65 or the Pneumonia Severity Index scores for complicated pneumonia, and the finding that neither CURB65 nor the Pneumonia severity index can reliably predict complicated pneumonia requires further study.

C-reactive protein $<100$ mg/L has a high negative predictive value for 30-day mortality, requirement for invasive ventilation and/or inotropic support, and for development of complicated pneumonia, suggesting that a low CRP can predict patients who may be safely discharged on clinical grounds. This study found that around 30% of patients presenting with community-acquired pneumonia will fall into this category. This is supported in the literature, where 25% of patients presenting with community-acquired pneumonia have a CRP $<100$ mg/L.\textsuperscript{5} C-reactive protein has the potential to accurately identify a significant proportion of patients presenting with community-acquired pneumonia as low risk.

One of the major advantages of CRP is that serial measurements can be taken as a marker of treatment response. Our study suggests that by using repeat measurements on day 4, as recommended by the British Thoracic Society, patients can be reclassified as low or high risk, leading to a significant improvement in risk stratification. Currently, objective severity assessment criteria are available only for patients on admission. There is no reason why severity assessment should end at the hospital “front door,” and the finding in this study that patients in whom CRP falls by 50% or more in 4 days have low 30-day mortality, need for mechanical ventilation and/or inotropic support, and complicated pneumonia should be of value to clinicians.

**CONCLUSION**

Low admission C-reactive protein levels $<100$ mg/L effectively excludes severe community-acquired pneumonia and can be used as an adjunct to clinical judgment to identify low-risk patients who may be safely discharged. C-reactive protein $<100$ mg/L provides a high negative predictive value comparable with CURB65 and PSI severity rules. In patients admitted to the hospital, a CRP level that falls by 50% or more in 4 days indicates a low risk of 30-day mortality, need for mechanical ventilation and/or inotropic support, or the development of complicated pneumonia.

**APPENDIX 1**

**Severity Assessment**

The Pneumonia Severity index (PSI) and the CURB65 score were used to assess severity of illness of presentation.

The PSI is a well validated prediction rule for 30-day mortality in CAP\textsuperscript{4} composed of the following characteristics:

- Demographics
  - Age
  - Sex
  - Nursing home residency

- Co-morbid illnesses
  - Neoplastic disease
  - Cerebrovascular disease
  - Congestive cardiac failure
  - Chronic renal disease
  - Chronic liver disease

- Physical examination findings
  - Altered mental status
  - Respiratory rate $>30$/min
  - Systolic blood pressure $<90$ mm Hg
  - Temperature $<35^\circ$C or $>40^\circ$C
  - Pulse $>125$/min

- Laboratory findings
  - pH $<7.35$
  - Blood urea $>10.7$ mmol/L
  - Sodium $<130$ mEq/L
  - Glucose $>13.9$ mmol/L

The ROC curves demonstrate that CURB65 and Pneumonia Severity Index had superior performance for predicting 30-day mortality, need for mechanical ventilation and/or inotropic support, and development of complicated pneumonia.
Haematocrit <30%
\(\text{PaO}_2<60\ \text{mm Hg}\)

Radiographic findings

- Pleural effusion

Using these data, patients were classified into 5 risk classes (I-V) according to the criteria created by Fine et al. Thirty-day mortality ranged from 0.1% for class I to 27% for class V in the original PORT cohort study.\(^4\)

CURB65 is a validated method of predicting inpatient mortality for CAP\(^3\) recommended by the British Thoracic Society. It consists of:

- New-onset mental confusion
- Urea \(>7\ \text{mmol/L}\)
- Respiratory rate \(\geq 30\ \text{breaths/min}\)
- Systolic blood pressure \(<90\ \text{mm Hg}\) or diastolic blood pressure \(\leq 60\ \text{mm Hg}\)
- Age \(\geq 65\ \text{years}\)

BTS guidelines suggest that patients with a score of 0-1 should be considered for outpatient treatment, patients with a CURB65 of 2 should be considered for short inpatient stay, and patients with CURB \(\geq 3\) have severe pneumonia requiring inpatient management, and that intensive care or high dependency environment care should be considered, particularly for patients with CURB65 \(\geq 4\).\(^7\)

References