SHORT REPORTS

Performance of SOAR (systolic blood pressure, oxygenation, age and respiratory rate) scoring criteria in community-acquired pneumonia: a prospective multi-centre study

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Abstract

Background: severity assessment in community-acquired pneumonia (CAP) is important as it is associated with significant mortality. In this study, we compared a previously suggested severity assessment rule for CAP-SOAR (systolic blood pressure, oxygenation, age and respiratory rate)- against the CURB-65 criteria.

Methods: we conducted a prospective study in three hospitals in Norfolk and Suffolk, UK. Consecutive patients with CAP were scored for severity with CURB-65 (n = 190), and SOAR (when there was sufficient information, n = 112). Mortality data was collected at 6 weeks.

Results: there were 100 males (53%). The age range was 18–101 years (mean 72 years, median 76 years). Sixty-five (34%) had severe pneumonia by CURB-65, and 56 patients out of 112 (50%) had severe pneumonia by SOAR. Patients with severe CAP were significantly more likely to be older, female, and to have higher urea levels and a lower PaO2:FiO2 ratio on admission. There were a total of 54 deaths during follow-up (33 of these in the SOAR-categorised group). There were 32 deaths (50%) in the severe and 22 deaths (18%) in the non-severe groups by CURB-65. There were 23 deaths (70%) in the severe and 22 deaths (30%) in the non-severe groups by SOAR. For CURB-65, sensitivity, specificity, positive and negative predictive values were 60.6, 72.2, 47.6 and 81.4%. For SOAR, the respective values were 69.7%, 58.2, 41.1 and 82.1%.

Conclusion: SOAR had demonstrably better sensitivity, but lower specificity compared with CURB-65 in this patient cohort. SOAR might be more suitable for assessing disease severity as an alternative or adjunct to CURB-65, particularly in the elderly.

Keywords: community-acquired pneumonia, severity assessment criteria, CURB-65, SOAR, older people

Introduction

Community-acquired pneumonia (CAP) is the fourth-most common cause of death in the UK [1], accounting for 83,000 hospital admissions annually [2]. Mortality in CAP is considerably higher in older people, ranging internationally between 16 and 40% [3, 4].

Identification of severe CAP is essential in guiding subsequent management. The British Thoracic Society (BTS) guidelines [5] for the treatment of CAP have recommended the CURB-65 criteria [6]. The usefulness of CURB-65, however, has been questioned, particularly in elderly patients [7]. CURB-65 does not perform as well in older patients when compared with younger patients [1, 8]. To address this,
we previously derived a new index, SOAR (systolic blood pressure, oxygenation, age and respiratory rate) [9].

In this study, we compared the usefulness of SOAR against CURB-65 for predicting mortality in CAP using audit data from three UK hospitals. We chose CURB-65 as the gold-standard criteria since it is routinely used in the UK, and comparable with the pneumonia severity index [10, 11] which is widely used in North America.

**Materials and methods**

We compiled data of prospective CAP audits from three UK hospitals in Norfolk and Suffolk; in each hospital the data were collected over a different time period (December 2006–January 2007; April 2007; April–August 2008). The methodology has been previously reported [3, 9]. For further details, including statistical methods, please refer to the Supplementary data available in Age and Ageing online, Appendix.

**Results**

One-hundred and ninety pneumonia cases were included in the study. There were 100 males (53%). The age range was 18–101 years (mean 72 years, median 76 years). All patients had sufficient recorded clinical data to be categorised by CURB-65, but only 112 patients had complete data for SOAR. This is due to the fact that arterial blood gas (ABG) data were not available for the remaining 78 patients, as ABGs were not performed in those where it was not indicated clinically. In 112 patients who had data for comparison of both criteria, there were 59 males (57%), and the age range was 23–94 years (mean 72 years, median 75 years).

Table 1 shows the sample characteristics comparing severe and non-severe cases by CURB-65 and SOAR. Patients with severe CAP using both criteria were significantly older, and were more likely to be women and had higher urea levels on admission. They were also more likely to have a lower PaO2:FiO2 ratio. There were no significant differences in white cell count (WCC) or body temperature between severe and non-severe CAP cases using both criteria. Interestingly, there were conflicting results between the two criteria with regard to confusion, systolic and diastolic blood pressures, CRP, haemoglobin, albumin, creatinine and mean length of hospital stay. For all of these variables, no significant difference was demonstrated in the data scored with SOAR between severe and non-severe CAP cases, whereas there was a significant difference demonstrated when CURB-65 was applied.

There were a total of 54 deaths (28%) during the 6-week follow-up, all of which occurred within 30 days of

| Table 1. Sample distribution of the variables included in CURB and other clinical, haematological and biochemical parameters stratified by severity (severe vs. non-severe) for CURB-65 and SOAR criteria |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Other variables                                      | Severe CAP ≥3 of CURB-65 | Non-severe CAP <3 of CURB-65 | *P*-value | Severe SOAR ≥2 of SOAR | Non-severe SOAR <2 of CURB-age | *P*-value |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Age, mean (sd)                                | 80.9 (10.5)                                 | 67.4 (17.6)                                 | <0.0001b                        | 77.4 (11.0)                                 | 66.8 (17.0)                                 | 0.00051b                          |
| Sex, Male, n (%)                              | 27 (42)                                     | 73 (58)                                     | 0.027*                          | 21 (37.5)                                   | 39 (57.9)                                   | 0.001c                          |
| Confusion, Yes, n (%)                        | 36 (55)                                     | 5 (4)                                       | <0.0001c                         | 17 (30.4)                                    | 9 (16.1)                                    | 0.073c                          |
| Urea, mean (sd)                               | 14.0 (8.4)                                  | 7.5 (5.0)                                   | <0.0001c                         | 12.9 (9.5)                                   | 8.4 (5.8)                                   | 0.0012c                         |
| Respiratory rate (rate/min), mean (SD)       | 27.8 (8.61)                                 | 23.2 (6.0)                                  | 0.0004b                         | 29.3 (8.6)                                   | 23.2 (5.2)                                  | 0.0001b                         |
| Systolic BP (mmHg), mean (SD)                 | 119.7 (30.7)                                | 133.5 (24.0)                                | 0.001b                          | 128.0 (34.4)                                 | 131.4 (23.9)                                | 0.265b                          |
| Diastolic BP (mmHg), mean (SD)                | 63.1 (16.1)                                 | 73.5 (12.2)                                 | <0.0001b                         | 67.9 (17.1)                                  | 71.2 (13.3)                                 | 0.139b                          |
| PaO2 (%)                                     | 84.9 (52.5)                                 | 72.2 (37.5)                                 | 0.593b                          | 90.0 (52.9)                                  | 72.9 (34.2)                                 | 0.349b                          |
| FiO2 (%)                                     | 55.4 (34.3)                                 | 34.0 (25.2)                                 | 0.0001b                         | 56.7 (34.1)                                  | 27.7 (18.0)                                 | <0.0001b                        |
| PaO2:FiO2 (%)                                 | 200.3 (107.8)                               | 254.6 (95.0)                                | 0.011b                          | 178.3 (90.1)                                 | 290.3 (82.9)                                | <0.0001b                        |
| WCC, mean (SD)                                | 15.4 (9.1)                                  | 13.9 (7.1)                                  | 0.334b                          | 15.4 (8.9)                                   | 15.1 (7.6)                                  | 0.919b                          |
| CRP, mean (SD)                                | 166.1 (132.8)                               | 128.7 (128.5)                               | 0.037b                          | 163.6 (146.6)                                | 137.7 (136.2)                                | 0.328b                          |
| Temperature, mean (SD)                        | 37.3 (1.4)                                  | 37.4 (1.1)                                  | 0.831b                          | 37.4 (1.3)                                   | 37.3 (1.2)                                  | 0.405b                          |
| Haemoglobin, mean (SD)                        | 12.1 (2.0)                                  | 13.2 (1.9)                                  | <0.0001b                         | 12.9 (2.1)                                   | 13.4 (1.6)                                  | 0.139b                          |
| Albumin, mean (SD)                            | 29.0 (4.5)                                  | 33.1 (5.9)                                  | <0.0001b                         | 30.5 (7.4)                                   | 31.5 (8.8)                                  | 0.822b                          |
| Creatinine, mean (SD)                         | 154.2 (74.1)                                | 114.7 (72.7)                                | <0.0001b                         | 155.5 (98.4)                                 | 130.3 (77.6)                                | 0.102b                          |
| Length of hospital stay (days), mean (SD)     | 15.0 (16.4)                                 | 12.5 (34.8)                                 | 0.0023a                         | 14.3 (14.5)                                  | 19.2 (51.8)                                 | 0.085b                          |
| Number of deaths at follow-up, n (%)          | 32 (49.2)                                   | 22 (17.6)                                   | <0.0001c                         | 23 (41.1)                                    | 10 (17.9)                                   | 0.007c                          |


Two-sample Wilcoxon rank sum test (Mann–Whitney test).

Chi-squared test.
admission. Sixty-five patients out of 190 (34%) had severe pneumonia by CURB-65 criteria. There were 32 deaths (59%) in the severe group and 22 deaths (41%) in the non-severe group by CURB-65. Fifty-six out of 112 patients (50%) had severe pneumonia by SOAR criteria. Thirty-three deaths occurred during follow up (all as in-patients within 30 days); 23 deaths (70%) in the severe group and 10 deaths (30%) in the non-severe group with SOAR.

Table 2 shows the sensitivity, specificity and positive predictive value (PPV)/negative predictive value (NPV) with both criteria, restricted to those patients with sufficient clinical data to be scored using SOAR. For this cohort, SOAR criteria showed slightly better sensitivity, but lower specificity, in predicting death after CAP compared with CURB-65. The PPV and NPV for each scoring system were broadly similar.

### Discussion

Our results demonstrate that CURB-65 and SOAR performed reasonably well in predicting mortality in CAP in this series. Although both scoring systems had comparable sensitivity and PPV/NPV, SOAR had lower specificity when compared against CURB-65. The results for SOAR were broadly similar to the results obtained by Myint et al. [9]; one noted difference was that the PPV was slightly higher and NPV slightly lower than those previously observed, probably as a result of the smaller sample size. The performance of CURB-65 in this cohort was comparable with that seen in previous studies [6, 12, 13].

The slightly better sensitivity of SOAR in our study might be attributable to its inclusion of the \( \text{PaO}_2: \text{FiO}_2 \) ratio, a good indicator of ventilation–perfusion mismatch which is usually present in severe pneumonia, as well as in other co-morbid cardio-respiratory conditions. This was reflected in our data, which showed that patients with severe CAP using both criteria were more likely to have a lower \( \text{PaO}_2: \text{FiO}_2 \) ratio. However, the accuracy of the calculated \( \text{PaO}_2: \text{FiO}_2 \) ratio might be limited by variability in the actual \( \text{FiO}_2 \) in restless older patients who are using oxygen delivered through masks or nasal cannulae. The requirement for ABG data to calculate the \( \text{PaO}_2: \text{FiO}_2 \) ratio would also limit the use of SOAR in the community setting.

We noted that the mortality rate for CAP was higher in this patient cohort than in our previous report [3]. A possible reason for this was the relatively advanced age of this cohort (median age 76), along with other co-morbid conditions related to advanced age. It may also be due to non-specific presentations and late diagnosis in the very elderly. The length of hospital stay was noted to be especially long, with a mean value close to or exceeding 2 weeks. This was likely to be due to a cohort effect of our largely elderly patient population, who would require a longer hospital stay due to their complex discharge needs.

Our study has limitations. The data collection was done by several different junior doctors. However, all investigators followed strict criteria for data collection, as described in the methods in previous reports [2, 3]. In addition, the criteria used to delineate severe and non-severe cases included only objective measures, eliminating most observer bias. Variation in clinical management between the three different sites may have been present, especially concerning hospital-specific practices such as local antibiotic guidelines. However, the practice in all three of the hospitals was to follow the BTS recommendations for the assessment and treatment of CAP [8], and so any residual variation in clinical practice between these sites was unlikely to have a significant effect on the results. The lack of ABG data for a proportion of our patients may have introduced a bias in the SOAR group, in that these patients were likely to be sicker since they were hypoxic enough to require ABGs. This limitation was unlikely to produce a significant effect, given that the results were similar to previous work [9].

The number of patients included in the study was modest at 190, and was even lower for the number suitable for scoring under SOAR (112). Nevertheless, the overall comparability of our results for SOAR with previous work [9] demonstrated that this sample size did not prevent us from demonstrating the possible usefulness of SOAR in predicting CAP mortality. Since the patients were enrolled at three different time periods, the resulting selection bias means that the number of cases included from each hospital may not be an accurate representation of CAP occurring in the corresponding catchment populations. We did not adjust for underlying pulmonary conditions such as COPD. However, it was reported that COPD patients do not differ from non-COPD patients in terms of the mortality outcome [14].

It is well recognised that the sensitivity of CURB-65 is low in older patients [1, 8]. Thus, some severe pneumonia cases are misclassified as non-severe using CURB-65 alone, despite the higher risk of mortality in these individuals. SOAR may also perform better in certain patient populations with a higher proportion of elderly individuals, such as nursing home residents [15]. Our study shows a 9% increase in sensitivity using SOAR criteria when direct comparison was made with CURB-65 on the same cohort of

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**Table 2.** Estimates and corresponding 95% confidence intervals for sensitivity, specificity, positive and negative predictive values for CURB-65 and SOAR criteria, with the sample population restricted to all those with information on SOAR \((n = 112)\).

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<tr>
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<th>CURB-65 estimate (95% CI)</th>
<th>SOAR estimate (95% CI)</th>
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<tr>
<td><strong>Sensitivity</strong></td>
<td></td>
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<td></td>
<td>60.6% (42.1–77.1)</td>
<td>69.7% (51.3–84.4)</td>
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<tr>
<td><strong>Specificity</strong></td>
<td>72.2% (60.9–81.7)</td>
<td>58.2 (46.6–69.2)</td>
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<td><strong>PPV</strong></td>
<td>47.6% (32.0–63.6)</td>
<td>41.1% (28.1–55.0)</td>
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<tr>
<td><strong>NPV</strong></td>
<td>81.4% (70.3–89.7)</td>
<td>82.1% (69.6–91.1)</td>
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patients. The requirement for ABG data is a particular disadvantage of SOAR, since UK guidelines only recommend an ABG in certain situations [16]. Nonetheless, a recalculation of severity using the SOAR criteria may improve the sensitivity of identifying severe CAP in these patients as opposed to using CURB-65 alone. The high NPV of SOAR would also help in excluding severe CAP, since those patients not scoring as ‘severe’ with either CURB-65 or SOAR criteria would be very unlikely to have severe CAP.

Our data reaffirm our previous work showing that the SOAR criteria may be a useful alternative or adjunct to CURB-65, particularly when ABG data are available and in older patients. Further work in larger cohorts of patients (focusing on those aged ≥65) across multiple different centres would be required to further validate the use of SOAR criteria in this setting.

Key points

• CAP is associated with significant morbidity and mortality.
• Several scoring systems have been devised to aid in assessment and management of CAP, but all have weaknesses when used in certain patient groups.
• This study compared the SOAR scoring criteria against the CURB-65 scoring criteria (commonly used in hospital practice in the UK) in a group of hospitalised patients from multiple different centres.
• SOAR had demonstrably better sensitivity, but lower specificity compared with CURB-65 in this patient cohort.
• SOAR criteria may be a useful alternative or adjunct to CURB-65 (particularly when ABG data are available, or in the elderly population), although further validation studies in larger cohorts of patients would be required to evaluate this.

Acknowledgements

We thank the Clinical Audit Departments of the following hospitals for their help and assistance with the project: The Queen Elizabeth Hospital, King's Lynn; The Ipswich Hospital, Ipswich; and the Norfolk and Norwich University Hospital, Norwich. We also thank the following individuals for their assistance with data collection: Hannah Ruffell, Alexandra Smith, and Philippa Prentice.

Conflicts of interest

None declared.

Supplementary data

Supplementary data mentioned in the text is available to subscribers in Age and Ageing online.

References


Received 22 August 2011; accepted in revised form 7 June 2012