CLINICAL RESEARCH STUDY

Prospective comparison of three validated prediction rules for prognosis in community-acquired pneumonia

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ABSTRACT

PURPOSE: We assessed the performance of 3 validated prognostic rules in predicting 30-day mortality in community-acquired pneumonia: the 20 variable Pneumonia Severity Index and the easier to calculate CURB (confusion, urea nitrogen, respiratory rate, blood pressure) and CURB-65 severity scores.

SUBJECTS AND METHODS: We prospectively followed 3181 patients with community-acquired pneumonia from 32 hospital emergency departments (January–December 2001) and assessed mortality 30 days after initial presentation. Patients were stratified into Pneumonia Severity Index risk classes (I–V) and CURB (0–4) and CURB-65 (0–5) risk strata. We compared the discriminatory power (area under the receiver operating characteristic curve) of these rules to predict mortality and their accuracy based on sensitivity, specificity, predictive values, and likelihood ratios.

RESULTS: The Pneumonia Severity Index (risk classes I–III) classified a greater proportion of patients as low risk (68% [2152/3181]) than either a CURB score <1 (51% [1635/3181]) or a CURB-65 score <2 (61% [1952/3181]). Low-risk patients identified based on the Pneumonia Severity Index had a slightly lower mortality (1.4% [31/2152]) than patients classified as low-risk based on the CURB (1.7% [28/1635]) or the CURB-65 (1.7% [33/1952]). The area under the receiver operating characteristic curve was higher for the Pneumonia Severity Index (0.81) than for either the CURB (0.73) or CURB-65 (0.76) scores ($P < 0.001$, for each pairwise comparison). At comparable cut-points, the Pneumonia Severity Index had a higher sensitivity and a somewhat higher negative predictive value for mortality than either CURB score.

CONCLUSIONS: The more complex Pneumonia Severity Index has a higher disciminatory power for short-term mortality, defines a greater proportion of patients at low risk, and is slightly more accurate in identifying patients at low risk than either CURB score.
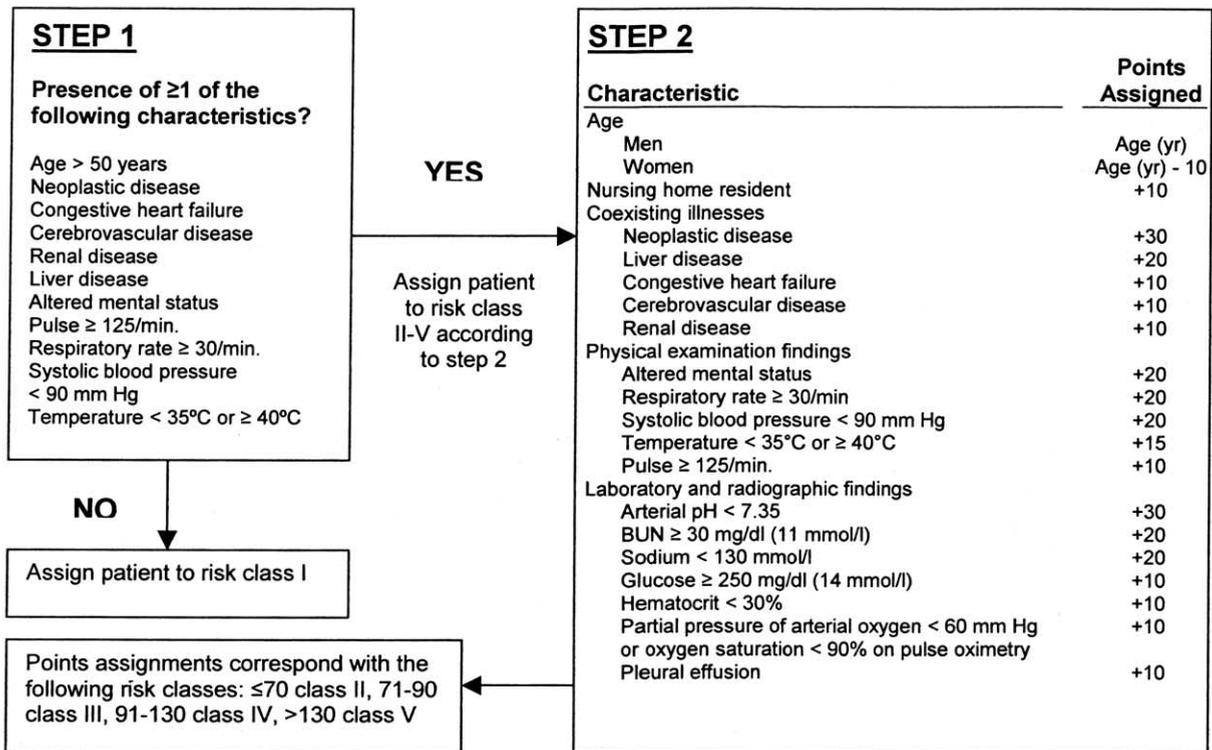© 2005 Elsevier Inc. All rights reserved.

Panel A. Risk Class Assignment based on the Pneumonia Severity Index

STEP 1

Presence of ≥1 of the following characteristics?

Age > 50 years
Neoplastic disease
Congestive heart failure
Cerebrovascular disease
Renal disease
Liver disease
Altered mental status
Pulse ≥ 125/min.
Respiratory rate ≥ 30/min.
Systolic blood pressure
< 90 mm Hg
Temperature < 35°C or ≥ 40°C

YES

Assign patient
to risk class
II–V according
to step 2

NO

Assign patient to risk class I

Points assignments correspond with the
following risk classes: ≤70 class II, 71-90
class III, 91-130 class IV, >130 class V

STEP 2

Characteristic	Points Assigned
Age	
Men	Age (yr)
Women	Age (yr) - 10
Nursing home resident	+10
Coexisting illnesses	
Neoplastic disease	+30
Liver disease	+20
Congestive heart failure	+10
Cerebrovascular disease	+10
Renal disease	+10
Physical examination findings	
Altered mental status	+20
Respiratory rate ≥ 30/min	+20
Systolic blood pressure < 90 mm Hg	+20
Temperature < 35°C or ≥ 40°C	+15
Pulse ≥ 125/min.	+10
Laboratory and radiographic findings	
Arterial pH < 7.35	+30
BUN ≥ 30 mg/dl (11 mmol/l)	+20
Sodium < 130 mmol/l	+20
Glucose ≥ 250 mg/dl (14 mmol/l)	+10
Hematocrit < 30%	+10
Partial pressure of arterial oxygen < 60 mm Hg or oxygen saturation < 90% on pulse oximetry	+10
Pleural effusion	+10

Panel B. Risk Stratum Assignment based on the CURB Severity Scores

Characteristic	CURB Severity Score Points Assigned	CURB-65 Severity Score Points Assigned
Respiratory rate ≥ 30/min.	1	1
Diastolic blood pressure ≤ 60 mm Hg or systolic blood pressure < 90 mm Hg	1	1
BUN > 19 mg/dl (7 mmol/l)	1	1
Presence of confusion (defined by an Abbreviated Mental Test Score ≤ 8 or new disorientation in person, place, or time)	1	1
Age ≥ 65 years	-	1

The CURB and CURB-65 total scores are calculated by adding the individual assigned points together. Patients with 0 points are
assigned to risk stratum 0, those with 1 point to risk stratum 1, etc.

Figure 1   Prediction rules for 30-day mortality for patients with community-acquired pneumonia. (**A**) Risk Class Assignment based on
the Pneumonia Severity Index. (**B**) Risk Stratum Assignment based on the CURB and CURB-65 severity scores. In all analyses, missing
values were assumed to be normal. CURB = confusion, urea nitrogen, respiratory rate, and blood pressure.

Physicians often use models of prognosis to quantify se-
verity of illness and guide the initial site of treatment decision
for patients with community-acquired pneumonia (designated
pneumonia).[1-8] The Pneumonia Severity Index was derived to
identify patients with pneumonia who are at low risk for
short-term mortality and potential candidates for outpatient
care.[9] Based on 20 clinical variables (Figure 1A), patients are

assigned into 5 risk classes with an increasing risk of 30-day
mortality. Patients in risk classes I–III are defined as low risk
for mortality and are considered potential candidates for out-
patient treatment.[1,2,5,8,9] Three prior interventional studies have
demonstrated that the clinical application of the Pneumonia
Severity Index safely decreases the proportion of hospital ad-
missions for low-risk patients.[10-12] Utilization of the Pneumo-

nia Severity Index for the initial risk assessment has been widely endorsed by organizations such as the Infectious Diseases Society of America and others.[1,2,5,8]

Based upon prediction rules originally developed to identify patients with severe pneumonia,[13,14] Lim et al described a prognostic model that stratifies patients into 5 strata of increasing risk of mortality.[15] In Lim's CURB score (confusion, urea nitrogen, respiratory rate, blood pressure), a total point score ranging from 0–4 is calculated based upon these 4 prognostic variables (Figure 1B). In a recent single site validation study, patients with a CURB score <1 had a low 30-day mortality that was comparable to that found in Pneumonia Severity Index risk classes I–III, leading to the conclusion that the relatively simple CURB score may replace the more complex Pneumonia Severity Index for identifying low-risk patients with pneumonia.[16] However, this study excluded 30% of the study patients in comparisons of the CURB and the Pneumonia Severity Index,[16] resulting in a potential selection bias.

A modified version of the CURB score, which added age ≥65 years as a fifth prognostic variable and stratifies patients into 6 strata of increasing risk of mortality, was recently derived and internally validated (Figure 1B).[17] The 2004 update of the British Thoracic Society pneumonia guidelines states that patients with a CURB-65 score <2 may be suitable for outpatient treatment.[4,18]

Despite such guideline recommendations, the CURB-65 score has never been externally validated. Nor has either CURB score been directly compared with the more complex Pneumonia Severity Index in an independent patient sample of pneumonia patients. Therefore, we sought to compare the performance of the Pneumonia Severity Index and the 2 versions of the CURB severity scores in predicting 30-day mortality in a large cohort of patients with pneumonia. Our a priori hypotheses were that the Pneumonia Severity Index would more accurately identify patients who are at low risk of 30-day mortality, whereas the two CURB scores would be superior at identifying pneumonia patients at high risk of mortality.

Methods

Study sites and patients

This study was conducted between January and December 2001 as part of a clinical trial to assess the effectiveness of 3 practice guideline implementation strategies (low, moderate, and high intensity) for pneumonia in 32 hospital emergency departments in Pennsylvania (n = 16) and Connecticut (n = 16).[19] The institutional review boards of all participating study sites approved all study procedures. The study design and characteristics of participating emergency departments were described previously.[19]

Potential study subjects were identified in all 32 participating emergency departments. Eligible patients were 18 years of age or older with a clinical diagnosis of pneumonia and a new radiographic pulmonary infiltrate. Patients were excluded if they were considered to have hospital-acquired pneumonia,

immunosuppression or co-morbid conditions that distinguished them diagnostically or therapeutically from pneumonia, or psychosocial problems incompatible with outpatient treatment, enrollment, or follow-up. Patients who were pregnant, previously enrolled, or enrolled in a competing research protocol were also excluded.[19] Patients with all inclusion criteria and no exclusion criteria documented were approached for informed consent to participate in the study.

Patient baseline assessment

For all enrolled patients, baseline demographic information (age, sex, nursing home residence) and clinical data were collected by medical record review by trained research nurses and recorded on a standard data collection instrument. The physical examination findings (pulse, respiratory rate, systolic and diastolic blood pressure, temperature, and mental status), comorbid conditions (neoplastic disease, liver disease, congestive heart failure, cerebrovascular disease, renal disease), and laboratory and radiographic results (arterial pH, blood urea nitrogen, sodium, glucose, hematocrit, level of arterial oxygenation, and pleural effusion) that comprise the Pneumonia Severity Index and the CURB severity scores were abstracted as part of the medical record review. For all physical examination, laboratory, and radiographic findings, the first available measurement after the time of presentation in the emergency department was recorded.

Patient outcomes assessment

All-cause mortality was assessed for all patients 30 days after initial presentation by patient interview and medical record review. Interviews were performed via telephone and were administered by trained interviewers. For this project, we excluded those patients for whom mortality could not be ascertained.

Clinical prognostic models

Based on patient demographics and baseline clinical data obtained by chart review, we determined the presence of the 20 Pneumonia Severity Index risk factors (Figure 1A) and all individual risk factors comprising the CURB and the CURB-65 severity scores (Figure 1B). For the 2 CURB scores, "presence of confusion" is defined using an Abbreviated Mental Test Score ≤8 or new disorientation to person, place, or time.[17] Due to the absence of these variables in the present study, "altered mental status" was used as a proxy measure for confusion. For any of the variables constituting the Pneumonia Severity Index or CURB scores, missing values were assumed to be normal. This strategy is widely used in the clinical application of prognostic prediction rules and reflects the methods used in the original derivation and validation of the Pneumonia Severity Index.[9,20] Based upon a 2-step algorithm (Figure 1A), all enrolled patients were classified into Pneumonia Severity Index risk classes I–V. Likewise, all patients were assigned to

5 risk strata based on the 4 prognostic factors in the original CURB score and 6 risk strata based on the 5 prognostic factors in the more recent CURB-65 score (Figure 1B).

Statistical analysis

We described 30-day mortality and mortality likelihood ratios by Pneumonia Severity Index risk class, as well as by CURB and CURB-65 risk strata. Likelihood ratios represent the degree to which the classification into a given risk class or stratum modifies the pretest probability of 30-day mortality.[21]

Based on commonly accepted definitions of low-risk patients (Pneumonia Severity Index risk classes I–III; CURB scores <1; and CURB-65 scores <2), pairwise comparisons of the proportions of patients classified as low risk by the 3 rules were made using McNemar's test.[22]

To determine the accuracy of each rule to predict 30-day mortality, we estimated sensitivity, specificity, and positive and negative predictive values for each possible cut-point to define high risk. We assessed the discriminatory power of each rule by calculating the area under each receiver operating characteristic curve, performing pairwise comparisons of the areas under the 3 curves.[23]

In a secondary comparison, we also tested whether a 2-step approach as used in the more complex Pneumonia Severity Index would improve the predictive performance of the CURB severity scores relative to the Pneumonia Severity Index. Patients in Pneumonia Severity Index risk class I were assigned a CURB and CURB-65 score of 0 (Step 1). The CURB and the CURB-65 scores were calculated in the remaining patients by adding 1 to the original score values (Step 2), converting the CURB score to a 5-point, 6-strata scale and the CURB-65 score to a 6-point, 7-strata scale. Overall 30-day mortality rates, mortality likelihood ratios, and the area under the receiver operating characteristic curves were calculated for each new CURB score.

We calculated an exact binomial 95% confidence interval (CI) for each test performance measure. For all analyses, a 2-sided P value <0.05 was considered to be statistically significant.

Results

Study sample

Of the 4506 identified patients with pneumonia who met eligibility criteria, 3615 (80%) were initially enrolled. Nonenrolled individuals tended to be older (mean age 74 vs. 63 years) and more likely to be resident in nursing homes (36% vs. 4.9%) than enrolled patients.

Table 1   Baseline characteristics of patients with pneumonia (n = 3181)

Characteristic*	Number (%)[†]
Demographic factors	
Age	
>50 years	2269 (71)
≥65 years	1747 (55)
Female sex	1641 (52)
White race	2726 (86)
Nursing home resident	130 (4)
Comorbid illnesses	
Congestive heart failure	431 (14)
Cerebrovascular disease	268 (8)
Cancer	87 (3)
Renal disease	108 (3)
Liver disease	29 (1)
Physical examination findings	
Temperature <35°C or ≥40°C	59 (2)
Pulse ≥125/min.	321 (10)
Systolic blood pressure <90 mm Hg	54 (2)
Diastolic blood pressure ≤60 mm Hg	587 (18)
Respiratory rate ≥30/min.	344 (11)
Altered mental status	123 (4)
Laboratory and radiographic findings	
Blood urea nitrogen	
>19 mg/dl (7 mmol/l)	1080 (34)
≥30 mg/dl (11 mmol/l)	467 (15)
Glucose ≥250 mg/dl (14 mmol/l)	176 (6)
Hematocrit <30%	150 (5)
Sodium <130 mmol/l	128 (4)
Oxygen saturation <90%	544 (17)
PaO2 <60 mm Hg	206 (6)
Arterial pH <7.35	72 (2)
Pleural effusion	464 (15)

*Data were missing for less than 2% of patients for all variables except blood urea nitrogen (21%), glucose (21%), hematocrit (17%), sodium (21%), oxygen saturation (4%), paO2 (81%), and arterial pH (81%). All laboratory tests were performed at the discretion of the managing medical providers.

†The numerator was the number of patients with the specific characteristic present (missing values were assumed to be normal). The denominator used was the total number of study patients (n = 3181).

After excluding 434 patients who either failed to meet eligibility criteria based on chart review (n = 293), were missing follow-up information for 30-day mortality (n = 57), lacked documentation of informed consent (n = 33), withdrew from participation (n = 32), or were missing chart review information (n = 19), 3181 patients comprised the final study sample (Table 1), of which 1094 (34%) were outpatients. Overall, 145 (4.6%) patients died within 30 days of presentation, mortality did not vary across intervention arms (4.7% [35/738] low-intensity, 3.9% [45/1150] moderate-intensity, and 5.0% [65/1293] for high-intensity arms; $P = 0.40$).

Comparison of mortality

The Pneumonia Severity Index classified a significantly greater proportion of patients as low risk (68%

Table 2 30-day mortality by risk strata derived from the 3 prediction rules

	Number (%)		Likelihood ratio for mortality
Prediction rule risk strata	Patients (n = 3181)	Deaths*	Parameter (95% confidence interval)
Pneumonia Severity Index risk class			
I	686 (22)	2 (0.3)	0.06 (0.03–0.2)
II	774 (24)	3 (0.4)	0.08 (0.03–0.3)
III	692 (22)	26 (3.8)	0.82 (0.6–1.2)
IV	829 (26)	67 (8.1)	1.8 (1.5–2.2)
V	200 (6)	47 (24)	6.4 (4.9–8.5)
CURB score			
0	1635 (51)	28 (1.7)	0.35 (0.3–0.5)
1	1035 (33)	49 (4.7)	1.0 (0.8–1.3)
2	431 (14)	53 (12)	2.9 (2.3–3.7)
3	73 (2)	12 (16)	4.1 (2.3–7.5)
4	7 (0.2)	3 (43)	16 (3.6–70)
CURB-65 score			
0	1051 (33)	6 (0.6)	0.12 (0.05–0.3)
1	901 (28)	27 (3.0)	0.65 (0.5–0.9)
2	775 (24)	47 (6.1)	1.4 (1.1–1.7)
3	383 (12)	51 (13)	3.2 (2.5–4.1)
4	64 (2)	11 (17)	4.4 (2.3–8.1)
5	7 (0.2)	3 (43)	16 (3.6–70)

CURB is an acronym for confusion, urea nitrogen, respiratory rate, and blood pressure.

*The denominator used was the number of patients per risk stratum. Mortality rates could not be statistically compared across prediction rules because the denominators differed.

[2152/3181]) than the CURB (51% [1635/3181]) and the CURB-65 (61% [1952/3181]) scores (P <0.001 for each pairwise comparison) (Table 2). Low-risk patients identified based on the Pneumonia Severity Index had a slightly lower aggregate 30-day mortality of 1.4% (31/2152) compared with 1.7% (28/1635) for low-risk patients identified using the CURB score and 1.7% (33/1952) for low-risk patients using the CURB-65 score. High-risk patients based on the Pneumonia Severity Index had a somewhat higher mortality of 11.1% (114/1029) compared with 7.6% (117/1546]) for high-risk patients based on the CURB score and 9.1% (112/1229) for high-risk patients based on the CURB-65 score. Although patients in the highest CURB and CURB-65 risk strata showed a higher mortality than those in the highest Pneumonia Severity Index risk class V (43% vs. 24%), these 2 CURB risk strata each included only 7 patients (0.2%) compared with 200 (6%) patients in Pneumonia Severity Index risk class V.

Comparison of predictive accuracy and discriminatory power

At every given threshold, the Pneumonia Severity Index had a higher sensitivity and a lower specificity than the two CURB scores (Table 3). The negative predictive values were high (>95%) across all thresholds for all prediction rules; the positive predictive values were low. The Pneumonia Severity Index had a greater discriminatory power to predict 30-day mortality than either CURB score (Figure 2).

Secondary comparison

If CURB scores <2 and CURB-65 scores <3 were used to define low-risk in the revised, 2-step severity CURB scores, 30-day mortality of low-risk patients was 1.6% (28/1711) for CURB and 1.7% (33/1955) for CURB-65 (Table 4). The corresponding areas under the receiver operating characteristic curves were 0.75 (95% CI: 0.71–0.78) for the revised CURB and 0.77 (95% CI: 0.74–0.80) for the revised CURB-65 scores, both significantly lower than for the Pneumonia Severity Index (0.81) (P <0.001, for each pairwise comparison).

Discussion

Our comparison shows that the Pneumonia Severity Index has a higher discriminatory power for predicting 30-day mortality than either CURB severity score. Low-risk patients identified using the Pneumonia Severity Index have a slightly lower mortality and a slightly higher negative predictive value for death than low-risk patients identified using either CURB severity score. Even when the CURB severity scores were converted into more complex, 2-step prediction rules using the Pneumonia Severity Index to identify the lowest risk strata, these results did not change markedly. Although the absolute difference in 30-day mortality based on the 3 prediction rules is small and of uncertain clinical relevance, the Pneumonia Severity Index classifies a significantly larger proportion of patients with

Table 3   Measures of performance in predicting 30-day mortality by prediction rule

Cut-points by prediction rule	Sensitivity	Percents (95% confidence interval)		
		Specificity	Positive predictive value	Negative predictive value
Pneumonia Severity Index risk classes				
≥II	99 (95–100)	23 (21–24)	6 (5–7)	99.7 (99–100)
≥III	97 (92–99)	48 (46–50)	8 (7–10)	99.7 (99–100)
≥IV*	79 (71–85)	70 (68–72)	11 (9–13)	99 (98–99)
V	32 (25–41)	95 (94–96)	24 (18–30)	97 (96–97)
CURB scores				
≥1*	81 (73–87)	53 (51–55)	8 (6–9)	98 (98–99)
≥2	47 (39–55)	85 (84–87)	13 (11–17)	97 (96–98
≥3	10 (6–17)	98 (97–98)	19 (11–29)	96 (95–97)
4	2 (0.4–6)	99.9 (99.7–100)	43 (10–82)	96 (95–96)
CURB-65 scores				
≥1	96 (91–99)	34 (33–36)	7 (6–8)	99.4 (99–100)
≥2*	77 (70–84)	63 (62–65)	9 (7–11)	98 (98–99)
≥3	45 (37–53)	87 (86–88)	14 (11–18)	97 (96–98)
≥4	10 (5–16)	98 (98–99)	20 (11–31)	96 (95–97)
5	2 (0.4–6)	99.9 (99.7–100)	43 (10–82)	96 (95–96)

CURB is an acronym for confusion, urea nitrogen, respiratory rate, and blood pressure.
*Cut-points that designate commonly accepted thresholds to define low vs. high-risk patients.

pneumonia as low risk than either CURB score. Because over 4 million cases of pneumonia occur in the United States per year,[24] utilization of the Pneumonia Severity Index would identify an additional 650 000 low-risk patients compared with the CURB and an additional 250 000 low-risk patients compared with the CURB-65, many of whom would be potential candidates for outpatient treatment. Given an average cost of care of $7500 for inpatients and $350 for outpatients with pneumonia,[25] the greater number of low-risk patients identified by the Pneumonia

Figure 2   Receiver operating characteristic curves for 30-day mortality for the Pneumonia Severity Index and the 2 CURB severity scores. The areas under the receiver operating characteristic curves were 0.81 (95% confidence interval [CI]: 0.78–0.84) for the Pneumonia Severity Index, 0.73 (95% CI: 0.68–0.76) for the CURB, and 0.76 (95% CI: 0.73–0.80) for the CURB-65 severity score (P <0.001, for each pairwise comparison). CURB = confusion, urea nitrogen, respiratory rate, and blood pressure.

Severity Index is likely to result in substantial cost savings. Although the Pneumonia Severity Index accurately identifies patients with pneumonia who are at low risk of short-term mortality and potential candidates for outpatient treatment, decisions pertaining to the initial site of treatment should include other clinical factors such as the presence of arterial hypoxemia, other coexisting illnesses that warrant hospital admission, and psychosocial problems that preclude outpatient care.[7,26,27]

Despite the fact that the 2 CURB scores are modified versions of the British Thoracic Society rule,[13] which was originally derived to identify patients with severe pneumonia, the Pneumonia Severity Index appears at least as useful as the CURB scores for identifying high-risk patients. Patients defined as high risk based on the Pneumonia Severity Index (risk classes IV/V) had a higher 30-day mortality than those identified by the CURB (score ≥1) or the CURB-65 (score ≥2) scores. If only the highest Pneumonia Severity Index risk class (V) and CURB[4] and CURB-65[5] risk strata are compared, the CURB severity scores show a higher mortality than the Pneumonia Severity Index. However, because only 0.2% of patients are classified in the 2 highest CURB risk strata, the practical usefulness of the highest CURB risk strata is of limited value in guiding clinical decision-making.

Due to the substantial proportion of outpatients included in our study, 30-day mortality was lower (4.6%) than in previous studies of pneumonia prognosis primarily focused on inpatients.[15-17,28] This explains why the negative predictive values for all 3 prediction rules were uniformly high, whereas the positive predictive values were generally low in our study cohort.
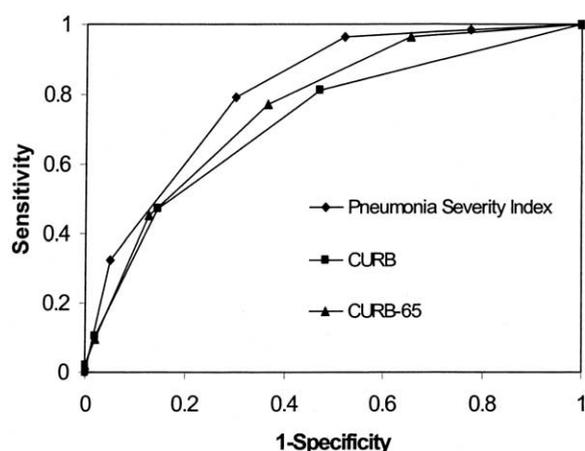
Table 4   Predictive performance of the CURB and CURB-65 severity scores when a 2-step approach is used*

Prediction rule risk strata	Number (%)		Likelihood ratio for mortality
	Patients (n = 3181)	Deaths[†]	Parameter (95% confidence interval)
CURB score			
0	686 (22)	2 (0.3)	0.06 (0.03–0.2)
1	1025 (32)	26 (2.5)	0.54 (0.4–0.8)
2	962 (30)	49 (5.1)	1.1 (0.9–1.4)
3	428 (13)	53 (12)	3.0 (2.3–3.7)
4	73 (2)	12 (16)	4.1 (2.3–7.5)
5	7 (0.2)	3 (43)	16 (3.5–70)
CURB-65 score			
0	686 (22)	2 (0.3)	0.06 (0.03–0.2)
1	441 (14)	4 (0.9)	0.19 (0.07–0.5)
2	828 (26)	27 (3.3)	0.71 (0.5–1.0)
3	772 (24)	47 (6.1)	1.4 (1.1–1.7)
4	383 (12)	51 (13)	3.2 (2.5–4.1)
5	64 (2)	11 (17)	4.3 (2.3–8.1)
6	7 (0.2)	3 (43)	16 (3.5–70)

CURB is an acronym for confusion, urea nitrogen, respiratory rate, and blood pressure.

*Patients in Pneumonia Severity Index risk class I were assigned a CURB and CURB-65 score of 0 (Step 1). In patients with a Pneumonia Severity Index of II–V (Step 2), the CURB and the CURB-65 scores were calculated by adding 1 to the original score values, converting the CURB score to a 5-point, 6-strata scale and the CURB-65 score to a 6-point, 7-strata scale.

†The denominator used was the number of patients per risk stratum. Mortality rates could not be statistically compared across prediction rules because the denominators differed.

Our study also demonstrates that the recently developed CURB-65 severity score is a better tool for predicting mortality than the CURB score:[17] the CURB-65 score showed a higher overall discriminatory power for mortality than the original CURB score. This finding underscores the importance of older age as a predictor of short-term mortality in pneumonia. However, in contrast to the study by Lim et al, in which a CURB-65 score <2 had a sensitivity of 93% in the derivation and 100% in the validation cohort,[17] the performance of the CURB-65 score was less impressive in our study: a CURB-65 severity score <2 had a sensitivity of 77% in our cohort. Indeed, the CURB-65 severity score, derived and internally validated in inpatients (with a 30-day mortality of 9%) appears to perform less well in an independent patient sample that includes both inpatients and outpatients.

A potential advantage of the CURB severity scores over the Pneumonia Severity Index is their simplicity and potential for greater ease of use in the clinical setting. The CURB and the CURB-65 scores consist of 4 and 5 clinical variables, including only 1 laboratory variable (blood urea nitrogen). In contrast, the Pneumonia Severity Index is comprised of 20 predictor variables, including 7 laboratory and radiographic variables. On the other hand, patients in Pneumonia Severity Index risk class I, who represent a substantial proportion of our study cohort (22%), can be identified solely on the basis of history and physical examination findings, without the need for any laboratory tests such as blood urea nitrogen. This makes the Pneumonia Severity Index useful in clinical settings where laboratory tests may not be available. The use of pocket cards, electronic handheld devices, or Internet support systems could further fa-

cilitate the application of the Pneumonia Severity Index in clinical practice.

There are several potential limitations to our study that should be acknowledged. First, our study sample may not reflect the full prognostic spectrum of patients with pneumonia because enrolled patients were younger than nonenrolled patients and less likely to be admitted from nursing homes. Thus, we cannot exclude the possibility that the 3 prediction rules would have performed differently in more severely ill patients. However, the 80% enrollment rate that we achieved is laudable for a multicenter clinical trial, and the enrolled patients reflect a broad spectrum of patient demographic and clinical characteristics. Second, in our analysis we assumed missing values for any of the predictor variables constituting the Pneumonia Severity Index and the CURB scores to be normal, a strategy previously validated for the Pneumonia Severity Index but not for the CURB scores.[9,20] Because information about blood urea nitrogen was not available in 21% of patients, we cannot exclude the possibility that disease severity may have been underestimated by the CURB scores that we calculated for this subgroup with missing values. Third, this study was performed within a clinical trial to compare 3 guideline implementation strategies of incremental intensity, and was not originally designed to compare different prediction rules for mortality. Thus, the CURB variable "presence of confusion," defined as an Abbreviated Mental Test Score ≤8 or new disorientation to person, place, or time, was not available and "altered mental status" had to be used as a proxy measure. Because 30-day mortality did not vary across study intervention arms, it is unlikely that this study design affected our study results.

In conclusion, the Pneumonia Severity Index has a significantly higher discriminatory power for predicting 30-day mortality than the 2 CURB severity scores in this large cohort of inpatients and outpatients with pneumonia. The more recently developed CURB-65 severity score recommended by the British Thoracic Society is superior to the CURB score in predicting mortality. The Pneumonia Severity Index is both more efficient and slightly more accurate in identifying low-risk patients with pneumonia who are potential candidates for outpatient care and at least as accurate as the CURB severity scores in identifying high-risk patients with this illness.

Acknowledgments

References

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