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ORIGINAL ARTICLE

On improving assessment of in-hospital mortality and ICU admission in community-acquired pneumonia patients using the eCURB

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KEYWORD

Community-acquired pneumonia eCURB

Abstract *Background:* Assessment of severity of the disease in community-acquired pneumonia (CAP) is very important to decide the site of care. The conventional CURB-65 score is composed of five separate elements namely, Confusion, Uremia, Respiratory rate, BP, and age $\geqslant$65 years. These elements could be calculated electronically. The electronic CURB (eCURB) utilizes the 5 CURB-65 data elements as continuous, weighted variables. The aim of this study was to evaluate the performance of eCURB elements in predicting in-hospital mortality and ICU admission in comparison to the conventional CURB-65.

Material and methods: This study was conducted upon 134 adult patients diagnosed as CAP and confirmed by radiographic findings, admitted to chest department, Assiut University Hospital, Egypt. The CURB-65 elements were retrospectively extracted from the medical records. The eCURB variables were introduced to electronically calculate the risk using the Excel appendix model (provided by Prof. *Nanthan Dean*, University of Utah, Salt Lake city, USA) and its predictive values and area under the receiver-operating characteristic (ROC) curve were compared with the conventional CURB-65 in predicting in-hospital mortality and the need for ICU admission.

Results: The study revealed that the conventional CURB-65 score could predict in-hospital mortality with an area under the curve (AUC) of 0.81 and the need for ICU admission with an AUC of 0.87. Using the eCURB-65 elements proved to be superior to the conventional CURB-65 in predicting in-hospital mortality with cut off point >7.5 and an AUC of 0.83 ($P < 0.0001$). Also, eCURB was better than conventional CURB-65 in predicting ICU admission with cut off point >3.8 and an AUC of 0.89 ($P < 0.0001$).

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Conclusions: Using the eCURB proved to be a valuable tool in predicting in-hospital mortality and ICU admission in patients with CAP with a significant superiority over conventional CURB-65 in both variables. Further prospective studies on a larger cohort are recommended.

Introduction

The outcome of CAP is extremely variable and depends upon the affected host's response, the underlying pathogen, and the treatment delivered. Assessment of severity of the patient's disease is very important to decide the site of care in CAP patients [4,5]. However; this decision could be variable according to the need for hospital admission [1]. Therefore, accurate severity assessment during initial management is critical.

Two severity assessment tools have become widely used by clinicians and approved for use by the ***ATS guidelines*** [1] to help distinguish high-risk patients who require inpatient management from those able to thrive with outpatient management. The first one is the pneumonia severity index (PSI) developed by ***Fine and colleagues*** [2] is a prognostic model that calculates a severity-of-illness score based on 20 separate patient characteristics, including underlying co-morbidities. The second one is the CURB-65 score that is composed of five separate elements: **C**onfusion, Uremia, Respiratory rate, BP, and age ⩾**65** years [3]. Although the PSI has been shown to be slightly more accurate at predicting outcome [4], CURB-65 is simpler to use. Additionally, all elements of the CURB-65 are routinely entered into the medical record, making it possible to generate an electronic mortality prediction for each patient at the point of care.

CURB-65 attributes a point to each criterion in an equally weighted fashion. However, excluding confusion, CURB-65 elements are actually continuous variables that may not be of equal predictive value. In other words, a systolic blood pressure of 85 mmHg is not like 70 mmHg although both are less than 90 mmHg and would be evaluated the same by the conventional CURB-65. So, the CURB-65 may be more accurate if calculated with continuous and weighted variables in the e-CURB model [5]. Instead of a severity score, a computer could generate an individualized mortality risk estimate using data elements from the electronic medical record. Generating an automated, accurate mortality estimate immediately available to providers could improve severity assessment and thus improve care [5]. The aim of this study was to validate the accuracy of the new, electronic version of CURB-65 (eCURB) to predict ICU admission and in-hospital mortality compared to conventional CURB-65.

Material and methods

The study was conducted upon 134 patients diagnosed with CAP attending chest department of Assiut University Hospital; a tertiary care teaching university hospital. Retrospective analysis of data from the electronic medical record was done to identify all adult patients with CAP from August 2010 to December 2011. All patients must have radiographic evidence of CAP otherwise excluded. Patients diagnosed with aspiration pneumonia, having immuno-compromised conditions, hematologic malignancies, and those meeting criteria for health-care-associated pneumonia were all excluded from the study. Vital signs, orientation status at presentation and the routine laboratory results that were done within the first 12 h were extracted from the electronic medical record.

The conventional CURB-65 score was calculated and its performance in predicting the need for ICU admission and in-hospital deaths was evaluated. The methodology of the eCURB required a specific value for blood urea nitrogen (BUN). Also, the Systolic BP was used, as it was found to be non-significantly better than using diastolic BP, and the latter did not add any additional predictive value [5]. The performance of eCURB risk score in predicting ICU admission and in-hospital mortality was calculated using an Excel appendix model (lasso penalized logistic regression model) that was provided to us from the original developer of the scoring system (Prof. *Nanthan Dean* from University of Utah, Salt Lake city, USA, Personal communication with Dr. ***Mohamed Metwally***, ATS meeting, Denver 2011) Fig. 1.

Instructions: Enter patient values into columns A through E.
Predicted mortality is provided in column U

Details: Age, BUN, and RR are transformed using the relevant "spline" lookup sheets.
The logistic regression estimate is produced in columns G through T.

Raw Patient Data					Spline Transformed Values												Results	
					Parmeter Estimates													
					-3.703	0.000	0.000	1.965	1.349	5.093	3.315	0.000	2.304	0.000	0.261	-0.006		
Age	Confused	First BUN	First RR	First SBP	Int	Age1	Age2	Age3	Confused	BUN1	BUN2	BUN3	RR1	RR2	RR3	SBP	Estimate	Final
35	0	12.88	21	100	1	-0.115	0.440	-0.282	0	-0.309	0.677	-0.344	-0.049	0.647	-0.340	100	-4.394	1.2%
70	0	13.44	25	140	1	0.539	0.361	-0.093	0	-0.314	0.703	-0.357	0.209	0.542	-0.255	140	-3.589	2.7%
40	0	9.24	20	110	1	-0.093	0.519	-0.332	0	-0.257	0.539	-0.274	-0.121	0.667	-0.352	110	-4.917	0.7%
65	0	17.92	26	110	1	0.478	0.407	-0.190	0	-0.285	0.730	-0.370	0.257	0.520	-0.230	110	-3.243	3.8%
53	0	6.16	19	100	1	0.167	0.537	-0.339	0	-0.162	0.332	-0.169	-0.181	0.671	-0.355	100	-5.211	0.5%
38	0	20.72	25	110	1	-0.106	0.492	-0.315	0	-0.242	0.716	-0.362	0.209	0.542	-0.255	110	-3.436	3.1%
70	0	25.2	25	140	1	0.539	0.361	-0.093	0	-0.174	0.691	-0.348	0.209	0.542	-0.255	140	-2.919	5.1%
66	0	11.2	40	130	1	0.495	0.397	-0.172	0	-0.298	0.641	-0.325	0.359	0.355	0.229	130	-3.337	3.4%
50	0	11.2	20	120	1	0.085	0.556	-0.354	0	-0.298	0.641	-0.325	-0.121	0.667	-0.352	120	-4.892	0.7%
28	0	11.2	26	130	1	-0.093	0.281	-0.180	0	-0.298	0.641	-0.325	0.257	0.520	-0.230	130	-3.707	2.4%
35	0	13.16	20	120	1	-0.115	0.440	-0.282	0	-0.314	0.703	-0.357	-0.121	0.667	-0.352	120	-4.623	1.0%

Patient Processing | spline.Age | spline.BUN | spline.RR

Figure 1 The excel appendix model (lasso penalized logistic regression model) for calculation of eCURB risk.

Table 1 Patients' demographics.

	No. (n = 134)	%
Sex		
Male	95/134	70.9
Female	39/134	29.1
Age/years: Mean ± SD	45.48 ± 16.58	
Current smokers	63/134	66.3
ICU admission	33/134	24.6
Died	16/134	11.9
CURB-65 classes		
0	60/134	44.8
1	35/134	26.1
2	15/134	11.2
3	9/134	6.7
4	8/134	6.0
5	7/134	5.2

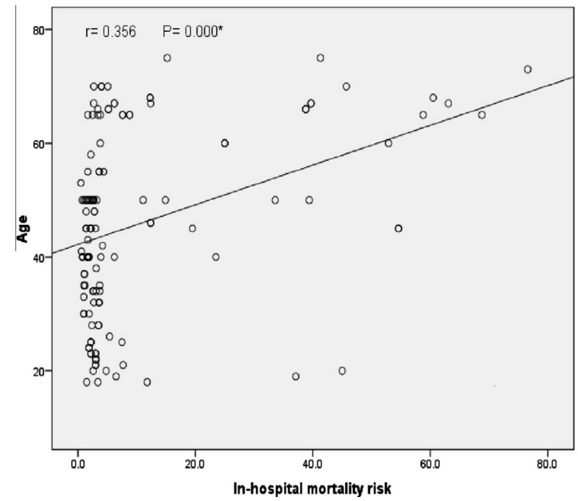

Figure 2 Correlation between eCURB in-hospital mortality risk and age.

Statistical analysis

All data were analyzed and processed using SPSS for windows, version 16.0.For comparison between groups, qualitative or categorical variables were compared using fisher's exact test. Quantitative continuous variables were compared using Mann–Whitney test. Predictive indexes as sensitivity, specificity, positive predictive values (PPV), negative predictive values (NPV) and diagnostic accuracy (DA) were calculated for different CURB-65 classes and for eCURB with ICU admission and death as outcomes. Receiver operating characteristic (ROC) curves and P values for differences between the discrete CURB-65 score and the logistic regression model were calculated [6].

Results

In this retrospective study, 134 patients with CAP were included. Their demographics are in Table 1 that shows different conventional CURB-65 classes with most of patients were in class 0 or 1 (44.8% or 26.1% respectively) while only 15 (11.2%) patients were in class 4 or 5. There was significant increase in ICU admission and in-hospital mortality in CURB-65 class $\geqslant$3 in comparison to lower classes [19 (79.2%), 7 (29.2%)] respectively with P value < 0.001 (Table 2). This study revealed that there was a highly significant positive correlation between of eCURB in-hospital mortality and age, first BUN and first respiratory rate [r = 0.356, r = 0.634, r = 0.590 respectively] with P value < 0.001 (Figs. 2–4). On the other hand, there was a significant negative correlation of eCURB in-hospital mortality and first systolic blood pressure (r = −0.284) as shown in Fig. 5. Using the eCURB elements proved to be superior to the conventional CURB-65 in predicting in-hospital mortality with cut off point > 7.5 that has the best sensitivity and specificity (Sensitivity = 81.25%, Specificity = 80.51%) and an area under the ROC curve (AUC) = 0.83 (P < 0 .0001) (Fig. 6), while conventional CURB-65 revealed an area under the ROC curve (AUC) = 0.81 to predict in-hospital mortality as shown in Fig. 7. The eCURB risk to predict ICU admission in patients with CAP had cut of point > 3.8 that had the best sensitivity and specificity (Sensitivity = 90.91%, Specificity = 79.21%) with an area under the ROC curve (AUC) = 0.89 with P value < 0.0001 as shown in Fig. 8 which was better than conventional CURB-65 with area under the ROC curve (AUC) = 0.87 (Fig. 9).

Discussion

Our study demonstrated that using the eCURB; that utilizes the 5 CURB-65 data elements as continuous, weighted variables, proved to be a valuable tool in predicting in-hospital mortality and ICU admission in patients with CAP with a

Table 2 ICU admission and in-hospital mortality in relation to conventional CURB-65 classes.

	CURB-65 classes								P value
	0 (n = 60)		1 (n = 35)		2 (n = 15)		3 or more (n = 24)		
	No.	%	No.	%	No.	%	No.	%	
ICU									
Yes	2	3.3	5	14.3	7	46.7	19	79.2	0.000*
No	58	96.7	30	85.7	8	53.3	5	20.8	
Died									
Yes	1	1.7	1	2.9	7	46.7	7	29.2	0.000*
No	59	98.3	34	97.1	8	53.3	17	70.8	

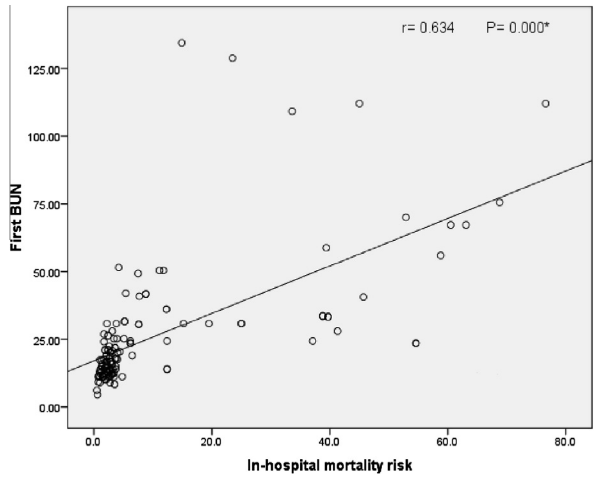

Figure 3 Correlation between eCURB in-hospital mortality risk and first (BUN).

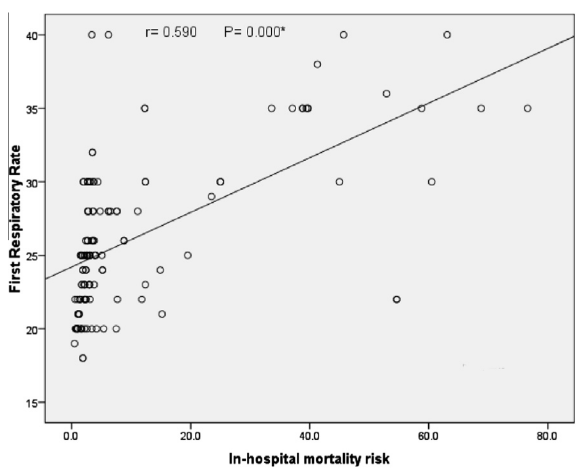

Figure 4 Correlation between eCURB in-hospital mortality risk and first respiratory rate.

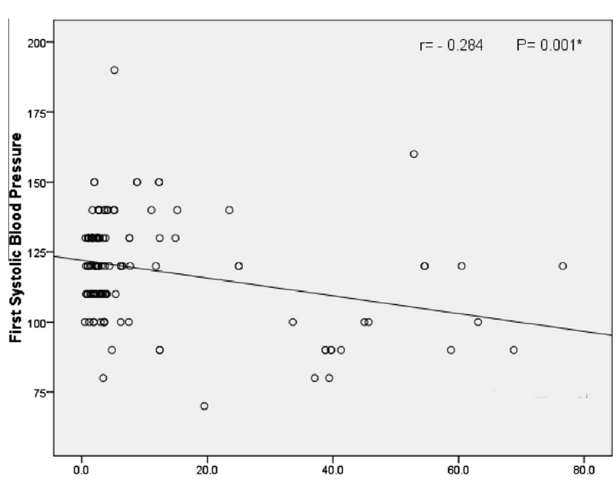

Figure 5 Correlation between eCURB in-hospital mortality risk and first systolic BP.

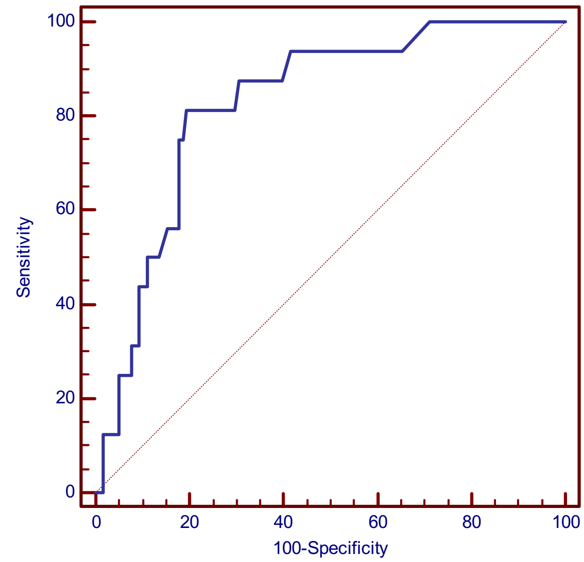

Figure 6 Receiver Operator Curves (ROC) for eCURB in predicting in-hospital mortality with AUC of 0.83 ($P < 0.0001$).

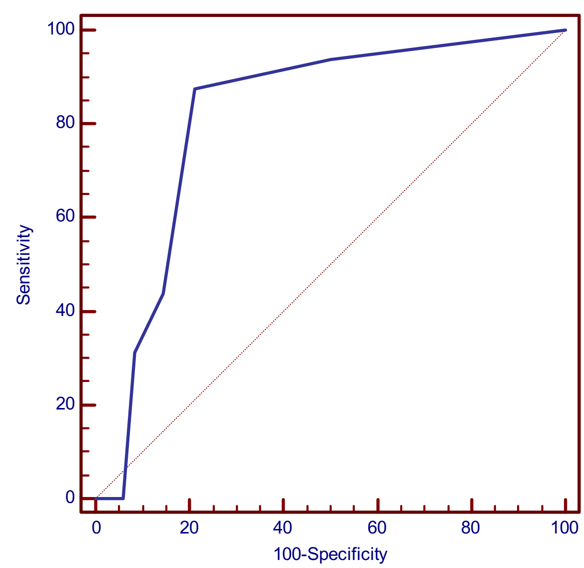

Figure 7 Receiver Operator Curves (ROC) for conventional CURB-65 in predicting in-hospital mortality with AUC of 0.81 ($P < 0.0001$).

significant superiority over the conventional CURB-65 in both outcomes. Up-to-our knowledge, this is the first study worldwide to evaluate the efficacy of the eCURB tool in predicting in-hospital mortality and ICU admission that make comparison of our results with previous studies a difficult task. Previous studies [5] have developed and validated the eCURB using data elements routinely entered in the electronic medical record and were able to show improvement in the predictive power over conventional CURB-65 in 30 day all-cause mortality in a multi center study. They used the eCURB to calculate a point estimate of risk for 30 day mortality, instead of lumping mortality risk near the cut-point estimates [5]. Patients whose data are near the cut-points may be more accurately assessed with eCURB than CURB-65. For example, a 64 year-old

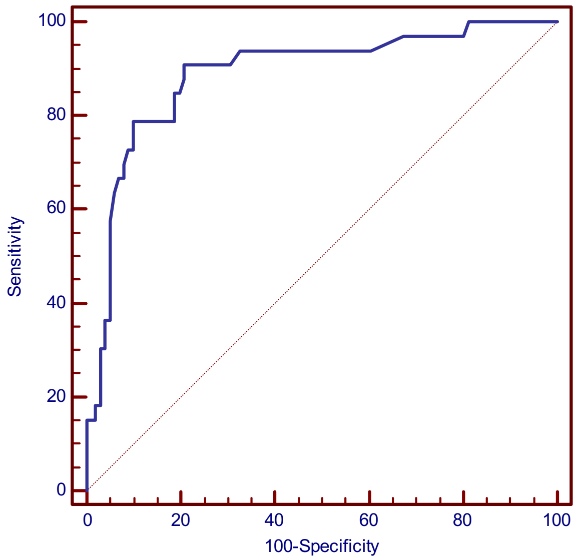

Figure 8 Receiver operator curves for eCURB in predicting ICU admission with AUC of 0.89 ($P < 0.0001$).

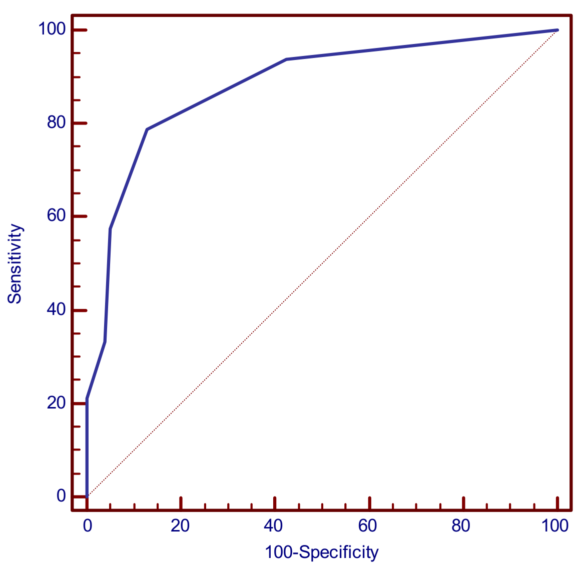

Figure 9 Receiver operator curves for conventional CURB-65 in predicting ICU admission with AUC of 0.87 ($P < 0.0001$).

man who is oriented with a BUN of 42 mg/dL, a BP of 92/62 mmHg, and a respiratory rate of 27/min, although scoring 1 by the CURB-65 (mortality rate 2%), would generate a mortality estimate of 13.3% by the eCURB. The methodology is very simple to use in emergency department, in the ward or out-patient by a computer, a laptop or personal data assistant (PDA).

In a study by Sanz et al. in 2011; they aimed to validate the accuracy of the new, electronic version of CURB-65 (eCURB) to predict hospital admission and 30-day mortality compared to CURB-65 and Pneumonia Severity Index (PSI) [7]. Their cohort was 1197 pneumonia patients from a prospective, epidemiological, multicenter, one-year study in Valencia, Spain. They proved that eCURB is better than CURB-65 and as accurate as PSI to predict 30 day mortality in their community-acquired pneumonia series.

In our series, we proved a highly significant statistic correlation between all eCURB data elements and in-hospital mortality, namely age, first BUN, first RR and first systolic blood pressure in Figs. 2–5 respectively. On comparison of the previously tested CURB-65 with the new eCURB, there was even better sensitivity and specificity in predicting in-hospital mortality with cut off point >7.5 that has the best sensitivity and specificity (Sensitivity = 81.25%, Specificity = 80.51%) and an area under the ROC curve (AUC) = 0.83 ($P < 0.0001$) (Fig. 6), while conventional CURB-65 revealed an area under the ROC curve (AUC) = 0.81 to predict in-hospital mortality (Fig. 7). The eCURB risk to predict ICU admission in patients with CAP had cut of point >3.8 that had the best sensitivity and specificity (Sensitivity = 90.91%, Specificity = 79.21%) with an area under the ROC curve (AUC) = 0.89 with P value < 0.0001 (Fig. 8) which was better than conventional CURB-65 with area under the ROC curve (AUC) = 0.87 (Fig. 9).

To conclude, we proved that using the eCURB is a valuable tool in predicting in-hospital mortality and ICU admission in patients with CAP with a significant superiority over conventional CURB-65 in both variables. Further prospective studies on a larger cohort are recommended.

Acknowledgement

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