ORIGINAL RESEARCH

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Frailty Enhances Prognostic Accuracy Compared to CURB-65 in Community-Acquired Pneumonia

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Abstract

Objective: Assessing the severity of community-acquired pneumonia (CAP) and selecting the appropriate care site is crucial for efficient management. Increased frailty is associated with poorer outcomes in both medical and surgical conditions. The objective of the study was to investigate how frailty affects the prognosis of CAP when assessed using frailty scales in combination with CURB-65.

Materials and Methods: The severity of the CAP was assessed utilizing the CURB-65 score and the pneumonia severity index (PSI). We assessed frailty using the FRAIL (F) score and the clinical frailty scale (CFS). New scores (CURB-65-F, CURB-65-CFS) were calculated by augmenting the CURB-65 score with patients' frailty status, and a comparative analysis of patients' mortality was conducted.

Results: One hundred twenty eight subjects (91 males) with a mean age of 60.10 ± 3.98 years were included in the study. While CURB-65-F and CURB-65-CFS had comparable effects on 30-day mortality compared with CURB-65 ($p = 0.001$, HR = 2.245; $p = 0.001$, HR = 2.374; $p = 0.005$, HR = 2.291, respectively), they were superior at 6 months [$p < 0.001$, hazard ratio (HR) = 1.813; $p = 0.001$, HR = 1.797; $p = 0.014$, HR = 1.635, respectively]. Receiver operating characteristic curves evaluating the discriminatory power to predict all-cause mortality, with scores and categories analyzed independently, showed that CURB-65-CFS and CURB-65-F had greater areas under the curve [area under the curve (AUC) = 0.690, 95% confidence interval (CI): 0.590–0.789; AUC = 0.687, 95% CI: 0.586–0.787 respectively] compared with CURB-65 (AUC = 0.614, 95% CI: 0.501–0.726).

Conclusion: In conclusion, using frailty scores to assess an individual's frailty may assist clinicians in more accurately estimating the mortality risk associated with CAP and in determining the site of care, with easy and rapid application at the bedside.

Keywords: Infection, severity, risk, prognosis, lung, scoring

Introduction

Community-acquired pneumonia (CAP), defined as a lung infection acquired outside the hospital, is one of the major causes of morbidity and mortality worldwide (1). The Global Burden of Disease Study revealed that lower respiratory tract infections caused 2,337,697 deaths (4.4% of all deaths) and 65,982,807 hospital admissions globally, across all age groups, from 1990 to 2016 (2). Ramirez et al. (3) reported 30-day and 1-year mortality rates of 13.0% and 30.6%, respectively, among patients hospitalized with CAP. Furthermore, a systematic review of readmission rates after hospitalizations for CAP showed that 20.1% of individuals were readmitted within 30 days and 46.0% within 1 year (4).

The selection of the site of care primarily depends on the severity of the CAP. Given mortality and readmission rates, it is crucial to identify appropriate individuals for hospitalization, mitigate

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hospitalization-related complications, and avoid unnecessary resource utilization. To this end, the most commonly used predictive models are the confusion-urea-respiratory rate-blood pressure (CURB)-65 score and the pneumonia severity index (PSI). CURB-65 is a simple 6-point tool applicable at the point of care that relies on confusion, urea level, respiratory rate, blood pressure, and age (>65 years) (5). Although it is effective in identifying patients at risk of death, it has reduced sensitivity in classifying patients at high risk of requiring admission to the ward or the intensive care unit (ICU), as it relies solely on severe clinical findings and age (6,7). On the other hand, PSI is a comprehensive, guideline-recommended tool that effectively distinguishes between low- and high-risk patients and demonstrates significant discriminative ability (8). Including information on patients' comorbidities, physical findings, and laboratory measures enables the PSI to comprehensively assess illness severity (9). However, the inclusion of 20 questions limits its practical application in daily settings.

Frailty is characterized by physical disability, difficulty with activities of daily living, increased vulnerability to adverse outcomes, and deterioration of cognitive function attributable to age (10,11). Individuals with increased frailty are more susceptible to negative impacts related to medical and surgical conditions (12-14). Recent studies indicate that frailty is strongly correlated with pneumonia severity and mortality risk (15,16). A study using data from 177,991 patients in the Japan Gerontological Evaluation Study showed that frailty was correlated with pneumonia incidence and hospitalization, even among functionally independent, community-dwelling individuals (17). To differentiate frail patients from non-frail patients, numerous screening tools have been developed to facilitate care planning and to determine the need for comprehensive geriatric evaluation (18-20). FRAIL (F) and the clinical frailty scale (CFS) are instruments that may be administered in a few minutes at the bedside, facilitating rapid evaluation in routine clinical practice.

The existing prediction tools for assessing the severity of CAP and determining the site of care primarily focus on chronological age and lack the capacity to assess patient frailty. Our aim was to investigate the impact of frailty on the prognosis of CAP using frailty scales in combination with CURB-65.

Methods and Materials

Study Population

We conducted a prospective observational study to examine the clinical data, laboratory results, and prognosis of patients with CAP. The study was conducted from October 2022 to October 2024 at Hacettepe University Hospital, a tertiary care center. The CURB-65 score and PSI were calculated at the time of admission. Additionally, we assessed the patients' frailty using the CFS and F scales. We recorded the site of care as outpatient, ward, or ICU (Figure 1).

Inclusion and Exlusion Criteria

Patients older than 18 years who were admitted to the emergency department and diagnosed with CAP were included in the study. We excluded individuals admitted in cardiopulmonary arrest; those who died within the first 24 hours after admission; patients diagnosed with CAP in another health facility and referred for further assessment; individuals receiving oral or parenteral antibiotic therapy as outpatients or inpatients and admitted due to treatment failure; patients diagnosed with pneumonia 48 hours or more after admission; those whose pneumonia diagnosis was not confirmed; and individuals under the age of 18.

Laboratory

On admission, we recorded the results of the complete blood count, renal and liver function tests, and acute-phase.

Assessment of Pneumonia

CAP was diagnosed in patients presenting with symptoms indicative of pneumonia, such as fever, cough, purulent sputum, fatigue, and dyspnea, and with pneumonic infiltrates detected on chest X-ray or thoracic computed tomography. We assessed the severity of pneumonia using the two most commonly used tools, CURB-65 and PSI. CURB-65 consists of three physical

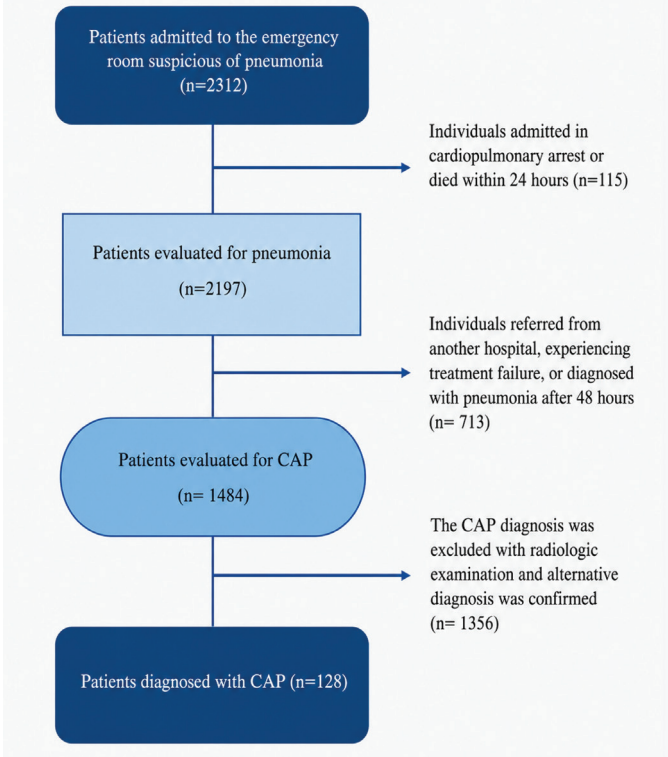

Figure 1. Patient selection flowchart.

CAP: Community-acquired pneumonia.

examination findings: confusion, respiratory rate >30/min, and systolic blood pressure <90 mm Hg; one laboratory measure: urea >20 mg/dL; and age >65 years. PSI is a more comprehensive test, including demographic information (age and gender), comorbidity data, laboratory measures, physical examination findings, and radiologic findings (Supplementary Table 1).

Frailty Assessment

Patient frailty was assessed using Turkish-validated versions of two widely used scales (21,22). The same geriatrician performed frailty assessments on all patients following confirmation of the CAP diagnosis. The F is an effortless tool that can be administered at the point of care. The decision depends on the patients' responses to yes-no questions regarding fatigue, difficulty climbing stairs, difficulty walking, presence of five or more chronic illnesses (including hypertension, diabetes, cancer, chronic lung disease, heart attack, congestive heart failure (CHF), angina, asthma, arthritis, stroke, and kidney disease), and weight loss (18,23). Each "yes" response was assigned 1 point, and a total above 2 points was classified as "frail" (Supplementary Table 2) (24).

Similarly, the CFS is easy to use at the point of care for frailty assessments. Conversely, it is based on clinical judgment, and patients are rated on a scale from 1 (very fit) to 9 (terminally ill). The higher scores indicate increased frailty. It is also dichotomized, with 1–4 points classified as non-frail and 5–9 points classified as frail (20,25) (Supplementary Table 3). Frailty status was determined based on the baseline clinical status assessed two weeks before admission.

Calculation of CURB-65 Plus Frailty Scores

First, we calculated CURB-65 and PSI scores to assess disease severity in the patient. We then divided the subjects into two groups: frail and non-frail. We considered patients frail if they scored 3 or more points on the F scale and 5 or more points on the CFS scale; we assigned +1 point to frail patients. We then calculated 7-point CURB-65-F and CURB-65-CFS scores separately. As is known, patients who receive 1 or more points on CURB, and those who receive 2 or more points on CURB-65, are considered at risk. We added one point for frail patients; therefore, a score of three on CURB-65-F and CURB-65-CFS was deemed high risk.

Follow-Up

We recorded total ward and ICU lengths of stay for hospitalized patients. Additionally, we assessed the patients' survival status for up to 6 months. We used the hospital database and the Ministry of Health's death notification system to ascertain survival status.

Ethical Approval

The study protocol complied with the Declaration of Helsinki and received approval from Hacettepe University Non-Interventional Clinical Research Ethics Committee (research number: GO 22/1168, decision number: 2023/02-38, date: 07.02.2023). Informed consent was obtained from all participants.

Statistical Analysis

Statistical analyses were performed using SPSS version 23. The variables were assessed using visual (histograms, probability plots) and analytical (Kolmogorov-Smirnov and Shapiro-Wilk tests) methods to determine whether they were normally distributed. Descriptive analyses were presented using means and standard deviations for normally distributed variables. We presented descriptive analyses using medians and ranges (minimum–maximum) for non-normally distributed or ordinal variables. We employed Pearson's test for normally distributed parameters and Spearman's test for non-normally distributed or ordinal parameters to estimate correlation coefficients and assess their significance. The univariate effects of gender, age, and other related factors were investigated using the log-rank test. The Kaplan-Meier survival estimates were calculated. The possible factors identified by univariate analyses were subsequently entered into a Cox regression analysis with backward selection to determine independent predictors of survival. Among correlated factors that had similar effects on survival, only those that were clinically significant were included. We assessed the proportional hazards assumption and model fit using Schoenfeld and Martingale residuals. The Hanley and McNeil approach was employed to compare the areas under the curves (AUCs). A p-value of less than 0.05 was considered statistically significant.

Results

Of the 128 patients included, the mean age was 60.10 ± 3.98 years; 91 (71.1%) were male. Of the individuals, 43 (33.5%) were current smokers, 41 (32.0%) were former smokers, and 44 (34.4%) were never smokers. The most common comorbidities were chronic obstructive pulmonary disease (COPD) (62, 48.4%), hypertension (58, 45.3%), coronary artery disease (CAD) (40, 31.3%), and diabetes mellitus (DM) and malignancy (each 36, 28.1%) (Tables 1 and 2).

The majority of patients had more than one symptom on admission: 122 (95.3%) had fatigue, 121 (94.6%) had cough, and 119 (93.0%) had dyspnea. The median CURB-65 score was 1 (range 0–4), the median PSI class was 4 (range 1–5), and 79 (61.7%) and 62 (48.4%) individuals were classified as low risk by CURB-65 and PSI, respectively. The median scores for both CURB-65-F and CURB-65-CFS were 2 (range 0–5). CURB-65-F classified 92 patients (71.9%) as low risk, whereas CURB-65-CFS classified 88 patients (68.8%) as low risk. A total of 115 individuals (89.8%) were hospitalized: 71 (55.5%) were in the ward and 44 (32.4%) were in the ICU (Table 3).

Table 1. Demographics and vaccination status according to groups.

Total patients: 128

	CURB-65		CURB-65-F		CURB-65-CFS		Total
	Low risk (79, 61.7%)	High risk (49, 38.3%)	Low risk (92, 71.9%)	High risk (36, 28.1%)	Low risk (88, 68.8%)	High risk (40, 31.3%)	
Age	56.8 ± 14.7	70.1 ± 9.1	57.9 ± 14.2	72.2 ± 8.4	57.5 ± 14.3	71.6 ± 8.4	60.1 ± 3.98
Gender (male)	56, 70.9%	35, 71.4%	66, 71.7%	25, 69.4%	62, 70.5%	29, 72.5%	91, 71.1%
Smoking status	Current: 25, 31.6% Former: 27, 34.2% Never: 27, 34.2%	Current: 16, 32.7% Former: 17, 34.7% Never: 16, 32.7%	Current: 31, 33.7% Former: 30, 32.6% Never: 31, 33.7%	Current: 10, 27.8% Former: 14, 38.9% Never: 12, 33.3%	Current: 28, 31.8% Former: 30, 34.1% Never: 30, 34.1%	Current: 13, 32.5% Former: 14, 35.0% Never: 13, 32.5%	Current: 41, 32.0% Former: 44, 34.4% Never: 43, 33.6%
Pneumococcal vaccine	32, 40.5%	30, 61.2%	40, 43.5%	22, 61.1%	38, 43.2%	24, 60.0%	62, 48.4%
Flu vaccine	2, 2.5%	1, 2.0%	2, 2.2%	1, 2.8%	2, 2.3%	1, 2.5%	3, 2.3%
COVID-19 vaccine	69, 87.3%	47, 95.9%	81, 88.0%	35, 97.2%	78, 88.6%	38, 95.0%	116, 90.6%

CURB: Confusion-urea-respiratory rate-blood pressure, COVID-19: Coronavirus disease-2019, F: FRAIL, CFS: Clinical frailty scale.

CURB-65, CURB-65-F, and CURB-65-CFS were correlated with the presence of certain diseases, including DM, hypertension, CAD, CHF, and COPD. A moderate correlation was observed between length of hospital stay and CURB-65-F ($p = 0.026$, $r = 0.196$) and CURB-65-CFS ($p = 0.034$, $r = 0.188$); no statistically significant correlation was observed with CURB-65. CURB-65, CURB-65-F, and CURB-65-CFS were strongly correlated with the PSI ($r = 0.695$, $p < 0.001$; $r = 0.817$, $p < 0.001$; $r = 0.814$, $p < 0.001$, respectively) (Table 4).

Cox regression analysis was used to determine the effect of CURB-65, CURB-65-F, and CURB-65-CFS on mortality using both overall and categorized scores. While the effect of CURB-65 on 30-day mortality [p: 0.005, hazard ratio (HR): 2.291, confidence interval (CI): 1.290-4.069] was comparable with CURB-65-F and CURB-65-CFS (p: 0.001, HR: 2.245, CI: 1.382-3.648; p: 0.001, HR: 2.374, CI: 1.373-3.767, respectively), CURB-65-F ($p < 0.001$, HR: 1.813, CI: 1.310-2.511) and CURB-65-CFS (p: 0.001, HR: 1.797, CI: 1.292-2.500) were superior to CURB-65 ($p = 0.014$, HR: 1.635, CI: 1.103-2.422) at the 6th month. When we categorized the patients as low- and high-risk according to each tool, the effects of CURB-65-F and CURB-65-CFS were more prominent than those of CURB-65 ($p = 0.002$, HR = 7.991, CI = 2.114-30.197; $p = 0.006$, HR = 6.539, CI = 1.734-24.664; $p = 0.022$, HR = 4.704, CI = 1.247-17.740, respectively) at 30 days and at 6 months ($p = 0.002$, HR = 3.553, CI = 1.562-8.083; $p = 0.004$, HR = 3.305, CI = 1.492-7.775; $p = 0.038$, HR = 2.391, CI = 1.048-5.458, respectively) (Tables 5 and 6).

Finally, we used ROC curves to assess the discriminatory power of CURB-65, CURB-65-F, CURB-65-CFS, and PSI to predict all-cause mortality by analyzing scores and categories independently. The tool with the greatest AUC was PSI (AUC = 0.716, 95% CI: 0.622-0.811), followed by CURB-65-CFS (AUC = 0.690, 95% CI: 0.590-0.789), CURB-65-F (AUC = 0.687, 95% CI: 0.586-0.787), and CURB-65 (AUC = 0.614, 95% CI: 0.501-0.726). On the other hand, when we categorized as low or high risk, CURB-65-F (AUC= 0.633, 95% CI: 0.521-0.745) and CURB-65-CFS (AUC= 0.630, 95%CI: 0.519-0.742) were superior to PSI and CURB-65 (AUC= 0.624, 95%CI: 0.518-0.731, and AUC= 0.582, 95%CI: 0.470-0.694, respectively) (Figure 2, Tables 7 and 8).

Discussion

Being one of the major causes of death and the leading infectious cause of death, CAP is a major public health issue (3,26). Therefore, it is crucial to rapidly diagnose and accurately manage the CAP. Following the diagnosis of CAP, clinicians face another challenge: deciding where, how, and for how long to treat it. CURB-65 is the most widely used clinical prediction tool due to its applicability at the point of care; however, it has limited sensitivity for identifying high-risk patients because it is based solely on chronological age (5). On the other hand, the PSI can differentiate between low- and high-risk patients, but the fact that it consists of 20 items makes it impractical in daily practice (8,27). Our tool, which adds frailty assessment to CURB-65, enables improved differentiation between low- and high-risk patients while preserving the advantage of rapid point-of-care examination.

Older age, chronic lung and heart diseases, DM, smoking, and excessive alcohol use were identified as risk factors for CAP (1,28). Furthermore, reports indicate a higher incidence of CAP in males (29). Our findings, which show a predominance of men and of patients with common comorbidities, are consistent with the literature and indicate that the study was grounded in real-world data. In contrast, our study group showed a markedly higher hospitalization rate (89.8%) than reported in the existing literature (30–42.7%) (3,30,31). This may be because our center is

Table 2. Comorbidities according to groups.

Total patients: 128							
	CURB-65		CURB65-F		CURB65-CFS		Total
	Low risk (79, 61.7%)	High risk (49, 38.3%)	Low risk (92, 71.9%)	High risk (36, 28.1%)	Low risk (88, 68.8%)	High risk (40, 31.3%)	
Diabetes mellitus	17, 21.5%	21, 42.9%	23, 25.0%	15, 41.7%	20, 22.7%	18, 45.0%	38, 29.7%
Hypertension	27, 34.2%	31, 63.3%	31, 33.7%	27, 75.0%	30, 34.1%	28, 70.0%	58, 45.3%
Coronary artery disease	20, 25.3%	20, 40.8%	25, 27.2%	15, 41.7%	23, 26.1%	17, 42.5%	40, 31.3%
Hyperlipidemia	3, 3.8%	5, 10.2%	4, 4.3%	4, 11.1%	4, 4.5%	4, 10.0%	8, 6.3%
Congestive heart failure	10, 12.7%	16, 32.7%	12, 13.0%	14, 38.9%	11, 12.5%	15, 37.5%	26, 20.3%
Atrial fibrillation	6, 7.6%	10, 20.4%	6, 6.5%	10, 27.8%	6, 6.8%	10, 25.0%	16, 12.5%
COPD	33, 41.8%	29, 59.2%	41, 44.6%	21, 58.3%	38, 43.2%	24, 60.0%	62, 48.4%
Asthma	9, 11.4%	5, 10.2%	11, 12.0%	3, 8.3%	10, 11.4%	4, 10.0%	14, 10.9%
Dementia	-	2, 4.1%	-	2, 5.6%	-	2, 5.0%	2, 1.6%
Cerebrovascular disease	1, 1.3%	6, 12.2%	1, 1.1%	6, 16.7%	1, 1.1%	6, 15.0%	7, 5.5%
Malign disease	19, 24.1%	17, 34.7%	20, 21.7%	16, 44.4%	20, 22.7%	16, 40.0%	36, 28.1%
Chronic renal disease	3, 3.8%	6, 12.2%	5, 5.4%	4, 11.1%	3, 3.4%	6, 15.0%	9, 7.0%
Chronic liver disease	2, 2.5%	1, 2.0%	2, 2.2%	1, 2.8%	2, 2.3%	1, 2.5%	3, 2.3%
Peripheric vascular disease	-	1, 2.0%	-	1, 2.8%	-	1, 2.5%	1, 0.8%
Connective tissue disease	1, 1.3%	3, 6.1%	2, 2.2%	2, 5.6%	2, 2.3%	2, 5.0%	4, 3.1%
Osteoporosis	1, 1.3%	2, 4.1%	1, 1.1%	2, 5.6%	1, 1.1%	2, 5.0%	3, 2.3%
Depression	1, 1.3%	3, 6.1%	3, 3.3%	1, 2.8%	3, 3.4%	1, 2.5%	2, 1.6%
Peptic ulcer	1, 1.3%	1, 2.0%	1, 1.1%	1, 2.8%	1, 1.1%	1, 2.5%	2, 1.6%
AIDS	-	-	-	-	-	-	-
Charlson CI	3.4 ± 2.7	5.8 ± 2.2	3.5 ± 2.6	6.4 ± 2.1	3.4 ± 2.6	6.3 ± 2.1	

AIDS: Acquired immunodeficiency syndrome, CI: Confidence interval, COPD: Chronic obstructive pulmonary disease, CURB: Confusion-urea-respiratory rate-blood pressure, F: FRAIL, CFS: Clinical frailty scale.

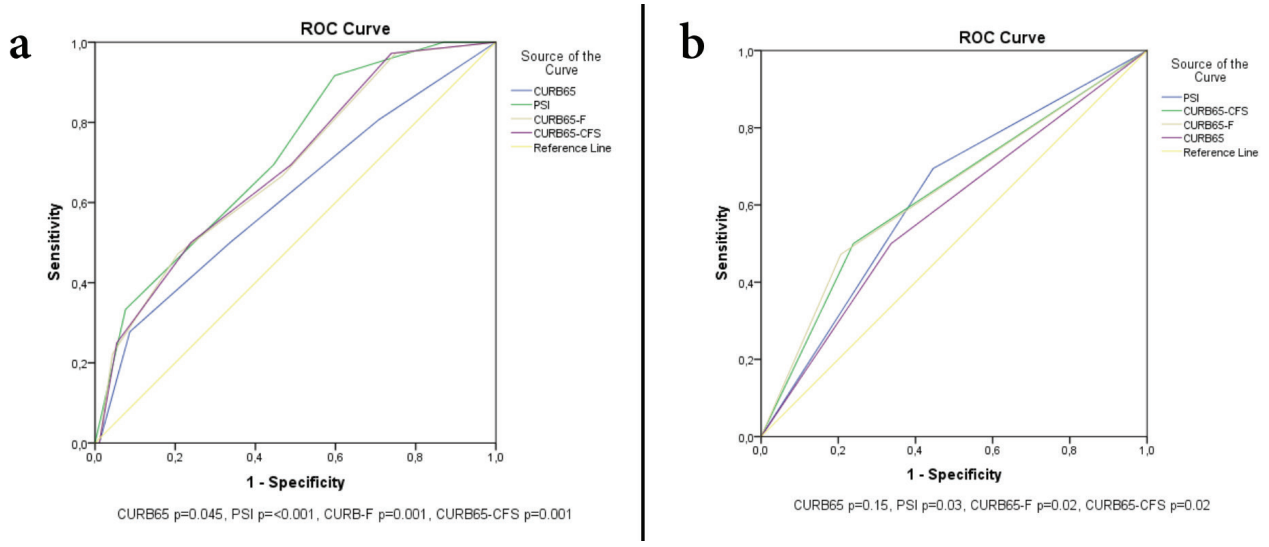

Figure 2. (**a**) ROC curves for CURB-65-F, CURB-65-CFS, and established tools CURB-65 and PSI for predicting all-cause mortality during the study period. (**b**) ROC curves for categorized (as low and high risk) CURB-65-F, CURB-65-CFS, CURB-65, and PSI for predicting all-cause mortality during the study period (represented by adding "c" at the end of the names).

CFS: Clinical frailty scale, CURB: Confusion-urea-respiratory rate-blood pressure, ICU: Intensive care unit, ROC: Receiver operating characteristic, F: FRAIL, PSI: Pneumonia severity index.

a tertiary care hospital, and patients who are too severe to be treated at local health centers are usually admitted. Moreover, high-risk patients with multiple comorbidities who were under our center's monitoring may have preferred to seek care at our hospital.

The American Thoracic Society and the Infectious Diseases Society of America recommendations endorse the PSI over CURB-65 for determining the site of care, since the PSI more reliably predicts 30-day mortality and identifies low-risk individuals (8,32). However, the fact that it comprises 20 parameters limits its usability in everyday practice. The practical one, CURB-65, is feasible in daily practice, but because it focuses solely on chronological age, it may underestimate risk in younger patients at elevated risk and overestimate risk in older patients at low risk (6). New tools have been proposed to increase the predictive power of CURB-65, but adding new parameters requires additional effort to collect data, thereby reducing the tool's usefulness (6,33). In this study, we found that adding a frailty assessment to the CURB-65 enhanced the evaluation of patient severity, outperforming the CURB-65 alone and approaching the accuracy of the PSI. It has been established that people with comorbid chronic diseases are at increased risk of frailty (11). As is well known, PSI includes several questions regarding the patient's chronic diseases. Given the association between comorbidities and frailty, we believe that adding a frailty assessment to the CURB-65 may better reflect the comorbidities of individuals assessed by the PSI.

Table 3. Clinical findings and laboratory results.

Hemoglobine	12.39 ± 0.65
WBC (10^3/µL)	13.23 ± 1.05
Neutrophyle (10^3/µL)	10.08 ± 0.87
Creatinine (mg/dL)	0.91 ± 0.11
BUN (mg/dL)	22.57 ± 3.95
ALT (U/L)	34.1 ± 8.0
AST (U/L)	40.2 ± 11.9
LDH (U/L)	275.4 ± 33.8
Sedimentation rate (mm/h)	36.9 ± 6.3
C-reactive protein (mg/L)	27.6 ± 6.0
Procalcitonin (ng/mL)	1.56 ± 0.93
Cough n, %	121, 94.5%
Sputum n, %	100, 78.1%
Dyspnea n, %	119, 93.0%
Fever n, %	49, 38.3%
Fatigue n, %	122, 95.3%
Palpitation n, %	41, 32.0%
Confusion n, %	11, 8.6%
Hypoxemia n, %	94, 73.4%
CURB-65 score	1 (0-4)
CURB-65 categorical (low risk) n, %	79 (61.7)
PSI class	4 (1-5)
CURB-65-Frail	2 (0-5)
CURB-65-CFS	2 (0-5)
CURB-65 categorical	Low risk: 92, 71.9%, (<3 points) High risk: 36, 28.1%, (≥3 points)
CURB-65-CFS categorical	Low risk: 88, 68.8%, (<3 points) High risk: 40, 31.3%, (≥3 points)
Site of care	ICU: 44, 33.4% Ward: 71, 55.5% Outpatient: 13, 10.2%

ALT: Alanine transaminase, AST: Aspartate Transferase, BUN: Blood urea nitrogen, CFS: Clinical frailty scale, CURB: Confusion-urea-respiratory rate-blood pressure, ICU: Intensive care unit, LDH: Lactate dehydrogenase, PSI: Pneumonia severity index, WBC: White blood cell, F: FRAIL.

CAP is associated with both short- and long-term mortality (3,34). Therefore, determining the site of care is crucial, because the aim is to manage all low-risk patients outside the hospital without patients at high risk of death who require more intensive care. CURB-65 and PSI were shown to predict 30-day mortality (5,9,27). Higher scores on both assessment tools are associated with increased mortality risk, and increasing scores prompt clinicians to admit patients to a ward or ICU. Additionally, a higher PSI class was shown to be associated with long-term mortality. In their study of mortality following pneumonia, Johnstone et al. reported a mortality rate of 12% at 30 days, 28% at 1 year and 53% at the end of the study, with a mean follow-up period of 3.8 years. In the analysis of the association of PSI with post-discharge deaths, it was observed that 15% of the patients in PSI classes 1-2 died after discharge, whereas 82% of the patients in PSI class 5 died (35). We followed patients for mortality for up to 6 months and found that CURB-65-F and CURB-65-CFS were comparable to CURB-65 during the first two months but superior to CURB-65 in the subsequent months. Furthermore, we observed that when we dichotomized patients into low- and high-risk groups across all tools, the superiority of CURB-65-F and CURB-65-CFS became more pronounced. Considering the relationship between frailty and mortality (36), we suggest that adding a frailty assessment to CURB-65 may better predict long-term mortality in patients with CAP.

Various tools, including CURB-65, expanded CURB-65, PSI, SMART-COP, and A-DROP, have been proposed for assessing CAP severity using clinical and laboratory data, specifically to predict 30-day mortality (6,9,37-39). PSI has been also suggested as a predictor of 6-month mortality (40). Additionally, certain frailty scales were evaluated to predict mortality risk associated with CAP. (15,41). Jabeen et al. (41) reported that the Frailty Index was inferior to PSI but superior to CURB-65 for predicting 30-day mortality in CAP. Similarly, Zhao et al. (15) study revealed that the F scale was strongly correlated with CURB-65 and with an increased risk of death in older adults. Consistent with current knowledge, our results indicated that assessment of patient

Table 4. Correlation of severity scores with other comorbidities, length of stay and pneumonia severity index.

	CURB-65		CURB-65-F		CURB-65-CFS	
Variables	**p**	**r**	**p**	**r**	**p**	**r**
DM	0.003	0.264	0.006	0.242	0.002	0.266
Hypertension	<0.001	0.331	<0.001	0.322	<0.001	0.307
CAD	0.002	0.276	0.006	0.243	0.004	0.252
Hyperlipidemia	0.015	0.214	0.017	0.210	0.016	0.212
CHF	<0.001	0.388	<0.001	0.376	<0.001	0.385
AF	0.004	0.253	0.001	0.302	0.001	0.308
COPD	**0.059**	**0.167**	**0.029**	**0.194**	**0.035**	**0.186**
Asthma	0.484	-0.062	0.243	-0.104	0.277	-0.097
Dementia	**0.089**	**0.151**	**0.054**	**0.171**	**0.066**	**0.163**
Cerebrovascular disease	0.014	0.217	0.006	0.242	0010	0.227
Malign disease	**0.164**	**0.124**	**<0.001**	**0.311**	**0.004**	**0.255**
Chronic renal disease	0.023	0.200	0.020	0.205	0.008	0.234
Chronic liver disease	0.800	0.023	0.295	0.093	0.377	0.079
Peripheric vascular disease	0.392	0.076	0.268	0.099	0.307	0.091
Connective tissue disease	0.124	0.137	0.085	0.153	0.118	0.139
Osteoporosis	0.205	0.113	0.220	0.109	0.254	0.102
Depression	0.330	0.087	0.543	0.054	0.650	0.040
Peptic ulcer	0.881	0.013	0.814	-0.021	0.922	0.009
Hospitalization duration	0.320	0.089	0.026	0.196	0.034	0.188
PSI	**<0.001**	**0.728**	**<0.001**	**0.817**	**<0.001**	**0.814**
PSI class	**<0.001**	**0.695**	**<0.001**	**0.779**	**<0.001**	**0.785**

PSI: Pneumonia severity index. CFS: Clinical frailty scale, CURB: Confusion-urea-respiratory rate-blood pressure, DM: Diabetes mellitus, CAD: Coronary artery disease, COPD: Chronic obstructive pulmonary disease, AF: Atrial fibrillation.

Table 5. Cox regression analysis shows the effects of CURB-65, CURB-65-F, and CURB-65-CFS scores on mortality.

Survival	Number of Events	CURB-65			CURB-65-F			CURB-65-CFS		p
		HR	CI	p	HR	CI	p	HR	CI	
1th month	11	2.291	1.290-4.069	0.005	2.245	1.382-3.648	0.001	2.374	1.373-3.767	0.001
2nd month	14	1.867	1.129-3.088	0.015	1.912	1.256-2.911	0.003	1.884	1.227-2.893	0.004
3rd month	18	1.738	1.115-2.710	0.015	1.884	1.300-2.731	0.001	1.842	1.264-2.684	0.001
4th month	19	1.763	1.144-2.716	0.010	1.917	1.336-2.751	<0.001	1.869	1.295-2.698	0.001
5th month	21	1.729	1.146-2.608	0.009	1.917	1.361-2.700	<0.001	1.858	1.312-2.631	<0.001
6th month	23	1.635	1.103-2.422	0.014	1.813	1.310-2.511	<0.001	1.797	1.292-2.500	0.001

One of the following parameters was included in the multiple regression analysis model: Age, gender, CURB-65, CURB-F, and CURB-CFS.
PSI: Pneumonia severity index. CFS: Clinical frailty scale, CURB: Confusion-urea-respiratory rate-blood pressure, DM: Diabetes mellitus, CAD: Coronary artery disease, CI: Confidence interval, HR: Hazard ratio, F: FRAIL.

frailty is essential for determining the site of care and predicting mortality, and that combining frailty scales with CURB-65 is more informative than CURB-65 alone. Using the FRAIL scale or CFS, physicians who already perform the CURB-65 assessment in emergency departments or outpatient clinics can evaluate patients' frailty levels with a few questions and, if the patient is frail, add one point to the CURB-65 score more accurately predict mortality.

Study Limitations

There are some limitations to our research. As mentioned above, our center functions as a tertiary care facility and typically accepts patients with more severe conditions, which is reflected in the hospitalization rates reported in the results. This limits the representativeness of the entire population, even though the study is based on real-life data. Additionally,

Table 6. Cox regression analysis shows the effects of categorized CURB-65, CURB-65-F, and CURB-65-CFS scores on mortality.

Survival	Number of Events	CURB-65			CURB-65-F			CURB-65-CFS		p
		HR	CI	p	HR	CI	p	HR	CI	
1th month	11	4.704	1.247-17.740	0.022	7.991	2.114-30.197	0.002	6.539	1.734-24.664	0.006
2nd month	14	2.391	0.829-6.996	0.107	4.128	1.428-11.930	0.009	3.336	1.157-9.624	0.026
3rd month	18	2.239	0.883-5.678	0.089	3.853	1.516-9.796	0.005	3.157	1.245-8.005	0.015
4th month	19	2.473	0.994-6.152	0.052	4.283	1.717-10.684	0.002	3.492	1.403-8.687	0.007
5th month	21	2.425	1.021-5.760	0.045	4.257	1.787-10.138	0.001	3.438	1.447-8.167	0.005
6th month	23	2.391	1.048-5.458	0.038	3.553	1.562-8.083	0.002	3.405	1.492-7.775	0.004

One of the following parameters was included in the multiple regression analysis model: Age, gender, CURB:-65, CURB:-F, and CURB:-CFS.
PSI: Pneumonia severity index. CFS: Clinical frailty scale, CURB: Confusion-urea-respiratory rate-blood pressure, DM: Diabetes mellitus, CAD: Coronary artery disease, CI: Confidence interval, HR: Hazard ratio, F: FRAIL.

Table 7. ROC analysis results.

	Area under curve	%95 confidence interval	p
Continuous			
CURB-65	0.614	0.501-0.726	0.045
PSI	0.716	0.622-0.811	**<0.001**
CURB-65-F	0.687	0.586-0.787	**0.001**
CURB-65-CFS	0.690	0.590-0.789	**0.001**
Categorical			
CURB-65	0.582	0.470-0.693	0.15
PSI	0.624	0.518-0.731	**0.03**
CURB-65-F	0.633	0.521-0.745	**0.02**
CURB-65-CFS	0.630	0.519-0.742	**0.02**

PSI: Pneumonia severity index. CFS: Clinical frailty scale, CURB: Confusion-urea-respiratory rate-blood pressure, ROC: Receiver operating characteristic, F: FRAIL.

Table 8. Comparison of AUCs.

	PSI	CURB-65-F	CURB-65-CFS
Continuous			
CURB-65	0.17	0.34	0.32
PSI	-	0.68	0.71
CURB-65-F		-	0.97
Categorical			
CURB-65	0.59	0.53	0.55
PSI	-	0.91	0.94
CURB-65-F		-	0.97

AUC: Area under curve, PSI: Pneumonia severity index, CURB: Confusion-urea-respiratory rate-blood pressure, F: FRAIL, CFS: Clinical frailty scale.

since the vast majority of patients were hospitalized, we were unable to compare inpatients and outpatients with respect to severity using established assessment tools. We acknowledge that the frailty scales employed were validated in older adults, while our study includes younger adults, which may limit the generalizability of the findings. Furthermore, the predominance of males in the population limits generalizability. Our analysis revealed a considerable age disparity between low-risk and high-risk groups. This pertains to age as a factor in frailty. Consequently, the proposed new scoring systems have considered chronological age and integrated frailty. On the other hand, prospectively collected data, including both clinical and laboratory information, serve as one of the major strengths of the current study. Examining frailty using two different scales facilitated a comparative analysis and enabled us to determine whether one of them is superior.

Conclusion

In conclusion, we are aware that clinical findings, admission measurements, laboratory results, comorbidities, and frailty are associated with morbidity and mortality in CAP. Nonetheless, obtaining all this data for every individual is neither feasible nor practical. Consequently, many tools exhibit specific limitations, including inapplicability to older or younger individuals, inability to identify high-risk patients, dependence on laboratory settings, or lack of usability in everyday practice. We believe that using CURB-65 together with frailty measured by F or CFS will allow us to determine the site of care and to predict mortality more accurately while maintaining bedside applicability.

Ethics

Ethics Committee Approval: The study protocol complied with the Declaration of Helsinki and received approval from Hacettepe University Non-Interventional Clinical Research Ethics Committee (research number: GO 22/1168, decision number: 2023/02-38, date: 07.02.2023).

Informed Consent: Informed consent was obtained from all participants.

Footnotes

Authorship Contributions

Surgical and Medical Practices: O.K., H.Ç., S.C., Concept: O.K., S.C., M.G.H., Design: O.K., A.B., M.E. Data Collection or Processing: H.Ç., D.A., A.İ., Analysis or Interpretation: O.K., S.C., A.İ., A.B.,

M.G.H., C.B., M.E. Literature Search: O.K., H.Ç., D.A., Writing: O.K., A.İ., A.B., E.Ö., M.G.H., C.B., M.E.

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