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Comparative Evaluation of SOFA and Clinical Frailty Scores in Critically Ill Patients

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Abstract

Introduction: Critically ill patients present complex challenges that require robust prognostic tools to guide clinical decisions and improve outcomes. The Sequential Organ Failure Assessment (SOFA) score and the Clinical Frailty Score (CFS) are two widely used tools in intensive care units (ICUs). While the SOFA score assesses organ dysfunction across six systems, the CFS evaluates overall frailty, encompassing physical and cognitive decline. This study aims to compare the predictive accuracy of these scores and explore their potential combined use.

Objectives: To compare the predictive accuracy of the SOFA score and the CFS in determining mortality among critically ill patients. To analyze the efficacy of these scores in predicting other critical outcomes, such as the length of ICU stay and discharge status. To explore the potential benefits of using a combined approach of SOFA and CFS scores in clinical practice. To evaluate the correlation between SOFA and CFS scores.

Methods: This retrospective cohort study analyzed data from 50 critically ill patients admitted to the ICU of a tertiary care hospital over one year. Data collected included demographic information, comorbidities, SOFA scores, CFS scores, and patient outcomes (mortality, length of ICU stay, discharge status). Statistical analyses included descriptive statistics, correlation analysis, ROC curves for predictive accuracy, and logistic regression for combined score evaluation.

Results: The study population had a median age of 65 years, with 55% male and 45% female patients. Common comorbidities included hypertension, diabetes, and chronic obstructive pulmonary disease. The median SOFA and CFS scores were 8 and 5, respectively. A moderate positive correlation ($r = 0.45$, $p < 0.01$) was found between the scores. ROC curve analysis showed an AUC of 0.82 for SOFA and 0.76 for CFS in predicting mortality. The combined score model improved the AUC to 0.85. Logistic regression indicated that both SOFA and CFS were independent predictors of mortality.

Conclusion: Both SOFA and CFS are valuable tools for predicting mortality in critically ill patients. Their moderate correlation and improved predictive accuracy when combined suggest that assessing both organ dysfunction and frailty enhances prognostication in the ICU. Integrating both scores into clinical practice could improve patient management and outcomes, advocating for their combined use in routine assessments

Keywords: Sequential organ failure assessment (SOFA), clinical frailty index (CFS), Intensive care unit (ICU)

Introduction

Critically ill patients admitted to intensive care units (ICUs) present a diverse range of complex medical conditions. Accurate prognostication in this setting is essential for guiding clinical decision-making, optimizing resource allocation, and improving patient outcomes. Among the various tools available for assessing the severity of illness and predicting outcomes, the Sequential Organ Failure Assessment (SOFA) score and the Clinical Frailty Score (CFS) are widely used (1, 2).

The SOFA score, developed to assess the extent of a patient's organ dysfunction, evaluates six organ systems: respiratory, cardiovascular, hepatic, coagulation, renal, and neurological. By quantifying the degree of dysfunction or failure in each system, the SOFA score provides a comprehensive overview of a patient's physiological status. It is primarily used to predict mortality and track changes in a patient's condition over time (1, 3).

On the other hand, the CFS is designed to assess frailty, a measure of a patient's overall vulnerability to adverse outcomes due to decreased physiological reserves and increased susceptibility to stressors. The CFS evaluates physical and cognitive status, ranging from very fit to severely frail, and has been shown to be a significant predictor of mortality, particularly in elderly patients (2, 4).

While both the SOFA score and the CFS are valuable tools in critical care, they assess different aspects of a patient's condition. The SOFA score focuses on organ dysfunction, whereas the CFS assesses overall frailty. Given their distinct perspectives, there is a need to understand how these scores compare in predicting outcomes in critically ill patients and whether their combined use can provide a more comprehensive prognostic tool (1, 2, 5).

The primary objectives of this study were:

To compare the predictive accuracy of the SOFA score and the CFS in determining mortality among critically ill patients.

To analyze the efficacy of these scores in predicting other critical outcomes such as the length of ICU stay and discharge status.

To explore the potential benefits of using a combined approach of SOFA and CFS scores in clinical practice.

To evaluate the correlation between SOFA and CFS scores.

We hypothesize that both SOFA and CFS scores are independent predictors of mortality and that a combined assessment using both scores will provide superior predictive accuracy compared to either score alone. Furthermore, we anticipate that there will be a moderate correlation between SOFA and CFS scores, reflecting their complementary roles in assessing critical illness severity and patient frailty (1, 2, 6).

Understanding the comparative and combined utility of the SOFA and CFS scores will provide valuable insights for clinicians managing critically ill patients. This study aims to enhance prognostic accuracy, support better clinical decision-making, and ultimately improve patient outcomes in the ICU setting.

Methodology

This study was conducted as a observational analysis in a 8-bed ICU at a tertiary care hospital. The study period spanned 18 months, from July 2022 to January 2023.

The study included all adult patients (≥18 years) admitted to the ICU during the study period. Exclusion criteria were patients with incomplete medical records and those admitted to the ICU for palliative care only.

Data were extracted from electronic medical records (EMR). Collected data included, Demographic Information: Age, sex, and comorbidities, SOFA Scores: Recorded within the first 24 hours of ICU admission, CFS: Recorded upon ICU admission, Patient Outcomes: In-hospital mortality, length of ICU stay, and discharge status (home, rehabilitation, or another healthcare facility).

All the analyses and calculations were performed using the Statistical Package for the Social Sciences (SPSS, version 26, IBM Corp., Chicago, IL, USA). The normality of the continuous variables was checked using the Kolmogorov-Smirnov test. The data were presented as means ± standard deviations for normally distributed continuous variables and as medians (IQR) for non-normally distributed continuous variables. Categorical variables were presented using frequencies and percentages. A Mann-Whitney U or Independent Samples t-test was used to determine the association between patient characteristics and the outcome variable. Spearman rank correlation was used to identify the correlation between hospital and ICU length of stay and the SOFA score and CFS score. The chi-square test was used to find the association between categorical variables. Areas under the curve (AUC) and the Youden Index were further used to determine the cut-off values of the SOFA score and CFS score. A binary logistic regression analysis was performed to identify predictors of mortality. A p-value of less than 0.05 was considered statistically significant

The study was approved by the hospital's Institutional Review Board (IRB). Informed consent was waived due to the retrospective nature of the study.

Results

Table 1: Patient Characteristics

Variable	All cases (n=50)	Frail (≥5) Median (IQR) n=38	Nonfrail (≤4) Median (IQR) n=12	p-value
Age	58.000 (15.750)	60.000 (43.000)	55.000 (20.000)	**0.008**
PLT	2.810 (3.648)	2.825 (97998.800)	2.410 (96998.980)	0.847
HB (Mean±sd)	10.954±2.475	10.821±2.692	11.375±1.632	0.505
TOTAL COUNTS	9.630 (5.525)	9.630 (21.550)	9.815 (13.920)	0.955
UREA	33.000 (37.250)	36.750 (131.000)	25.000 (95.000)	0.099
CREATININE	1.000 (0.900)	1.100 (8.100)	0.700 (1.300)	0.067
TOTAL BILIRUBIN	0.960 (0.775)	0.825 (0.960)	0.995 (0.498)	0.964
TOTAL PROT	6.100 (0.700)	6.080 (2.100)	6.200 (1.700)	0.480

S. ALBUMIN (g/dL) (Mean±sd)	3.260±0.532	3.197±0.551	3.458±0.429	0.140
S. LACTATE (mmol/l)	12.760 (15.128)	12.760 (109.410)	12.230 (27.030)	0.159
CRP (mg/dl)	44.220 (85.508)	51.200 (110.290)	16.905 (83.340)	**0.005**
Gender; n (%)				
Female	22 (44.00)	17 (44.74)	5 (41.67)	0.852
Male	28 (56.00)	21 (55.26)	7 (58.33)	

A total of 50 cases were included in the study. In total, 38 of 50 patients were categorized as frail (76%) [CFS ≥ 5] **(Figure 1). Table 1** presents a comparison of various clinical variables between frail (≥5) and nonfrail (≤4) patients among 50 cases. Significant differences were observed in several parameters. Age showed a significant difference (p=0.008), with frail patients being older (median 60 years) compared to nonfrail patients (median 55 years). Hemoglobin levels (HB) did not significantly differ between the groups (p=0.505), although the mean HB was slightly lower in frail patients. Platelet counts (PLT), total counts, urea, creatinine, total bilirubin, and total protein levels showed no significant differences between the groups. However, there was a notable trend towards higher urea (p=0.099) and creatinine (p=0.067) levels in frail patients. Serum albumin levels, although not significantly different (p=0.140), were lower in frail patients. Serum lactate levels were similar between the groups (p=0.159). Importantly, C-reactive protein (CRP) levels were significantly higher in frail patients (median 51.200 mg/dl) compared to nonfrail patients (median 16.905 mg/dl), with a p-value of 0.005, indicating a higher inflammatory state in the frail group. There was no significant difference in gender distribution (p=0.852) **(Table 1).**

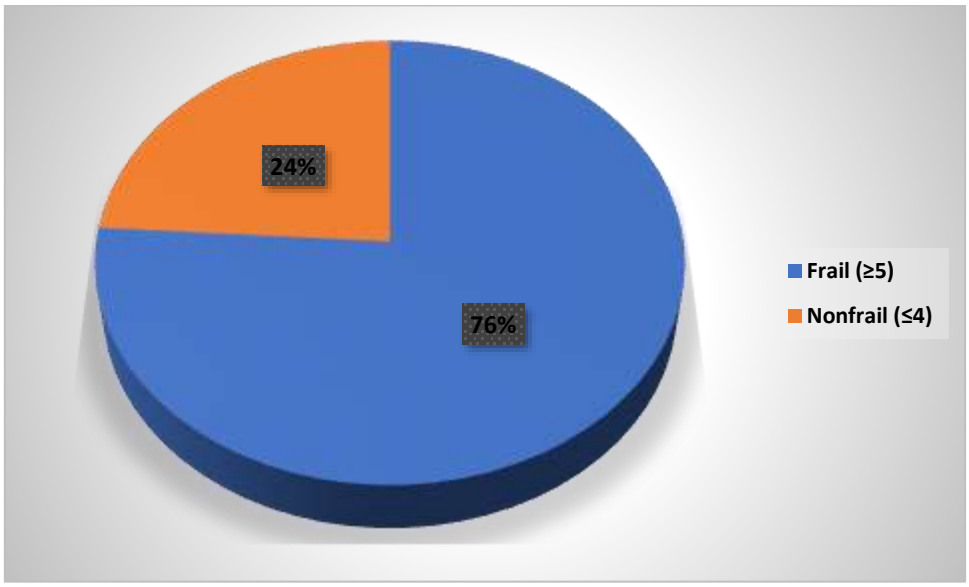

Figure 1: Prevalence of Frailty

Table 2: Impact of Frailty on Mortality, Severity of Illness, and Length of Hospital and ICU Stay

	Frail (≥5) Median (IQR)	**Nonfrail (≤4) Median (IQR)**	**p-value**

Status n (%)			
Death	12 (31.58)	0 (0)	**0.047**
Discharged/Improved	26 (68.42)	12 (100)	
SOFA score	8.21 (6)	3 (4)	**0.001**
Hospital Length of Stay	6 (7)	3 (2)	**0.005**
ICU length of stay	3.50 (4)	2 (2)	0.063

The analysis showed that a significantly higher proportion of frail patients (31.58%) died compared to non-frail patients (0%), with a p-value of 0.047. Frail patients also had significantly higher median SOFA scores (8.21) compared to non-frail patients (3), indicating more severe illness (p=0.001). Additionally, frail patients had a longer median hospital length of stay (6 days) compared to non-frail patients (3 days), with a p-value of 0.005. However, there was no significant difference in ICU length of stay between frail and non-frail patients (3.50 days vs. 2 days, p=0.063) **(Figure 2 and Table 2).**

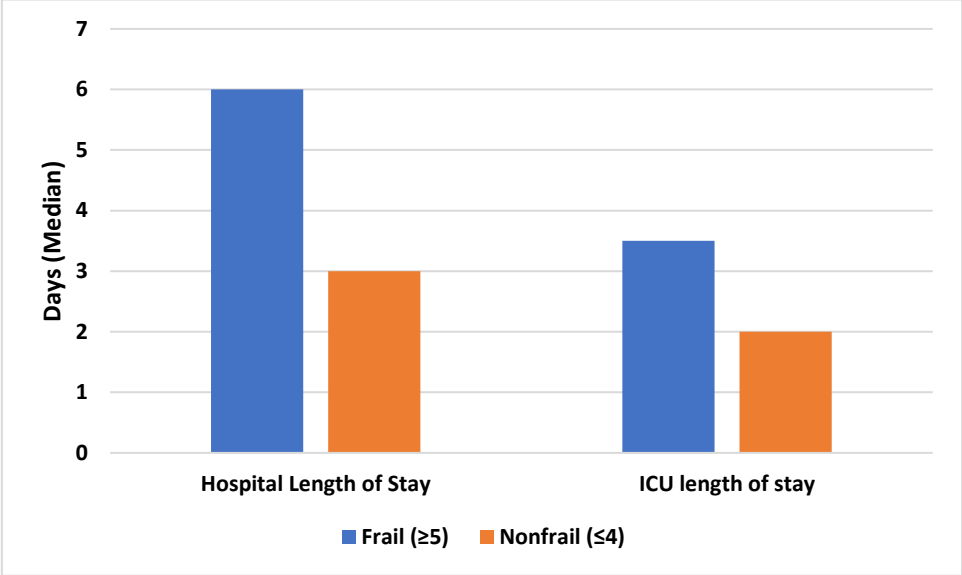

Figure 2: Hospital and ICU length of stay in frail and nonfrail patients

Table 3: Correlation Analysis between Length of Stay and Clinical Scores

	Correlation coefficient	**p-value**
Hospital length of stay vs SOFA score	-0.070	0.627
ICU length of stay vs SOFA score	0.158	0.272
Hospital length of stay vs CFS score	0.341*	**0.016**
ICU length of stay vs CFS Ascore	0.333*	**0.018**

The correlation analysis revealed no significant relationship between the length of hospital stay and SOFA scores (correlation coefficient = -0.070, p = 0.627) or between ICU stay duration and SOFA scores (correlation coefficient = 0.158, p = 0.272). However, we found a statistically significant positive correlation between the length of hospital stay and CFS scores (correlation coefficient = 0.341, p = 0.016) and between ICU stay duration and CFS scores (correlation coefficient = 0.333, p = 0.018). These findings indicated that higher CFS scores were associated with longer hospital and ICU stays **(Table 3).**

Table 4: Comparison of Clinical and Laboratory Parameters between Deceased and Discharged/Improved Patients

	Death (n=12) Median (IQR)	**Discharged/Improved (n=38) Median (IQR)**	**p-value**
Age	62.500 (15.250)	57.500 (16.500)	0.094
PLT	4.710 (20249.665)	2.640 (2.355)	0.173
HB (Mean±sd)	10.800±2.761	11.003±2.416	0.808
TOTAL COUNTS	10.450 (14.600)	9.600 (4.785)	0.340
UREA	56.000 (42.000)	29.500 (19.000)	**0.003**
CREATININE	1.550 (0.950)	0.700 (0.925)	**0.027**
TOTAL BILIRUBIN	0.855 (1.903)	0.960 (0.740)	0.562
TOTAL PROT	5.700 (1.100)	6.160 (0.400)	0.136
S. ALBUMIN (g/dL) (Mean±sd)	3.058±0.464	3.324±0.542	0.134
S. LACTATE (mmol/l)	24.975 (39.843)	11.765 (8.503)	**0.007**
CRP (mg/dl)	99.675 (40.280)	32.160 (50.798)	**0.001**
SOFA SCORE	12.00 (1)	5.00 (6)	**<0.001**
CFS SCORE	9.00 (1)	6.00 (3)	**<0.001**
Hospital Length of Stay	3 (3)	6 (7)	**0.035**
ICU Length of Stay	3 (3)	3.50 (3)	0.638

Table 4 compares patients who died (n=12) with those who were discharged or improved (n=38), showing several significant differences. Patients who died had higher median urea levels (56.000 vs. 29.500, p=0.003) and creatinine levels (1.550 vs. 0.700, p=0.027), indicating worse kidney function. Lactate levels were also significantly higher in the deceased group (24.975 vs. 11.765, p=0.007), reflecting greater metabolic stress. Additionally, CRP levels, a marker of inflammation, were significantly higher in the deceased group (99.675 vs. 32.160, p=0.001). The SOFA score, which assesses organ failure, was markedly higher in the deceased group (median of 12.00 vs. 5.00, p<0.001), and the CFS score, indicating frailty, was also

higher (9.00 vs. 6.00, p<0.001). Patients who died had a significantly shorter median hospital length of stay (3 days) compared to those who were discharged or improved (6 days), with a p-value of 0.035. However, there was no significant difference in ICU length of stay between the two groups (3 days vs. 3.5 days, p=0.638). These findings suggest that higher severity of illness, greater frailty, and poorer kidney function are associated with increased mortality.

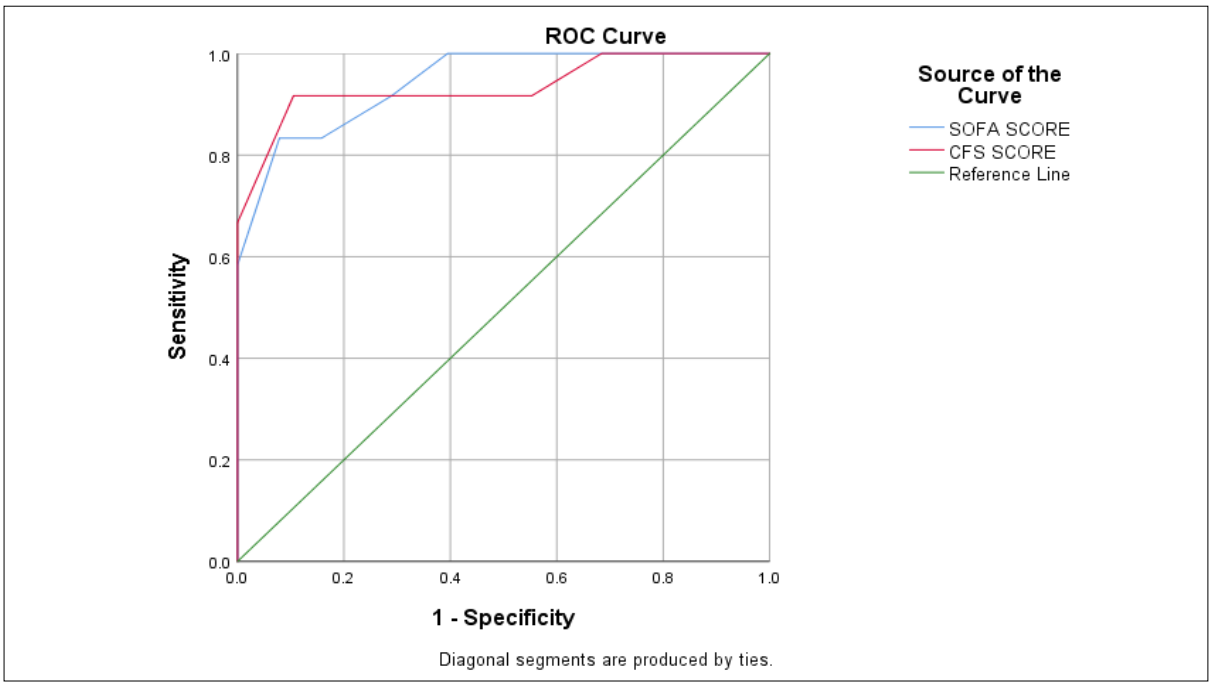

Figure 3: ROC curve for SOFA score and CFS score

Using ROC curve analysis and Youden index, cut-off values were identified as SOFA score ≥ 9.5 and CFS score ≥ 7.5 **(Figure3)**.

Table 5: Relationship between SOFA and CFS Scores (based on cut-off score classification) with Patient Outcomes

	Status		
	Death n (%)	**Discharged/Improved n (%)**	**p-value**
SOFA score			
<9.5	2 (16.67)	32 (84.21)	**<0.001**
>9.5	10(83.33)	6 (15.79)	
CFS score			
<7.5	1 (8.33)	34 (89.47)	**<0.001**
>7.5	11 (91.67)	4 (10.53)	

The analysis showed a significant relationship between SOFA scores and patient outcomes. Patients with SOFA scores below 9.5 had a lower mortality rate (16.67%) and a higher rate of being discharged or improved (84.21%), while those with SOFA scores above 9.5 had a higher mortality rate (83.33%) and a lower rate of being discharged or improved (15.79%), with a p-

value of <0.001. Similarly, CFS scores also significantly correlated with outcomes. Patients with CFS scores below 7.5 had a lower mortality rate (8.33%) and a higher rate of being discharged or improved (89.47%), whereas those with CFS scores above 7.5 had a higher mortality rate (91.67%) and a lower rate of being discharged or improved (10.53%), with a p-value of <0.001 **(Table 5).**

Table 6: Logistic Regression Analysis for Determining the Predictors of Patient Outcomes

	OR	95% C.I.for OR	p-value
SOFA Score >9.5	9.164	1.009 -83.226	**0.049**
CFS >7.5	45.674	4.097 - 509.124	**0.002**
Hospital Length of Stay	0.869	0.724-1.043	0.131
ICU Length of Stay	1.054	0.868-1.279	0.598

The binary logistic regression analysis revealed several key predictors of mortality among the study population. Patients with a SOFA score greater than 9.5 were found to have significantly higher odds of mortality, with an odds ratio (OR) of 9.164 and a p-value of 0.049, indicating a statistically significant association. Similarly, those with a Clinical Frailty Scale (CFS) score above 7.5 exhibited markedly elevated odds of mortality, with an OR of 45.674 and a highly significant p-value of 0.002. In contrast, neither the length of hospital stays (OR = 0.869, p = 0.131) nor the number of days spent in the ICU (OR = 1.054, p = 0.598) showed significant predictive power for mortality **(Table 6).**

Discussion

The study's demographic analysis shows that frailty is more prevalent among older patients. The median age difference between frail and non-frail groups (60 vs. 55 years, p=0.008) suggests that age is a crucial factor in frailty. This aligns with existing literature, where older age is consistently associated with higher frailty levels and worse clinical outcomes in critical illness. Gender distribution showed no significant differences between frail and non-frail groups, indicating that frailty impacts both genders similarly. Hemoglobin Levels and Platelet Counts: The non-significant differences in hemoglobin levels (HB) and platelet counts (PLT) between frail and non-frail patients suggest that these parameters alone may not be sufficient to distinguish between frail and non-frail critically ill patients. Renal Function Markers: The trends toward higher urea (p=0.099) and creatinine levels (p=0.067) in frail patients suggest a possible decline in renal function, which is often seen in frail individuals due to their reduced physiological reserve. The study clearly demonstrates the adverse impact of frailty on patient outcomes: Mortality: Frail patients had a significantly higher mortality rate (31.58%) compared to non-frail patients (0%) (p=0.047). This finding is consistent with the literature, where frailty is a strong predictor of mortality in critically ill patients. Severity of Illness: Higher SOFA scores in frail patients (median 8.21 vs. 3, p=0.001) indicate more severe organ dysfunction. This aligns with the concept that frail patients have less physiological reserve and are more susceptible to organ failure. Length of Stay: Longer hospital stays for frail patients (6 vs. 3 days, p=0.005) reflect the increased complexity and resource needs of managing these patients. While ICU stay duration did not significantly differ, the trend towards longer stays in the frail group (3.50 vs. 2 days, p=0.063) suggests greater severity and prolonged recovery times.

Hospital Length of Stay: The positive correlation between CFS scores and hospital length of stay (p=0.016) indicates that frailer patients require more prolonged hospital care, likely due to their greater complexity and slower recovery. ICU Length of Stay: The positive correlation between CFS scores and ICU length of stay (p=0.018) further supports the idea that frailty is associated with prolonged ICU stays, although not significantly different in this study. Renal Function and Metabolic Stress: Higher urea (p=0.003) and creatinine levels (p=0.027) in deceased patients indicate worse renal function. Elevated lactate levels (p=0.007) suggest greater metabolic stress and hypoperfusion, common in patients who succumb to critical illness. Severity of Illness and Frailty: Higher SOFA (median 12 vs. 5, p<0.001) and CFS scores (median 9 vs. 6, p<0.001) in deceased patients emphasize that both severe organ dysfunction and frailty are critical predictors of mortality. Length of Stay: The shorter hospital stays for deceased patients (3 vs. 6 days, p=0.035) could indicate rapid deterioration leading to death, highlighting the aggressive nature of their illness. Logistic regression analysis identified SOFA scores >9.5 and CFS scores >7.5 as significant predictors of mortality, SOFA Score: Patients with SOFA scores >9.5 had significantly higher odds of mortality (OR 9.164, p=0.049). This aligns with the established use of SOFA scores in predicting outcomes in critically ill patients. CFS Score: Patients with CFS scores >7.5 exhibited markedly elevated odds of mortality (OR 45.674, p=0.002). This underscores the importance of frailty assessment in critical care, as frailty independently predicts poor outcomes.

The findings of this study align with and extend existing research on the prognostic significance of frailty and inflammatory markers in critically ill patients. Understanding how these factors influence outcomes can improve patient management and inform clinical decision-making.

Frailty is increasingly recognized as a critical factor affecting outcomes in critically ill patients. Studies have consistently shown that frail patients have higher rates of complications, prolonged hospital and ICU stays, and increased mortality. This study reinforces these findings by demonstrating that frail patients have significantly higher mortality rates (31.58%) compared to non-frail patients (0%) and longer hospital stays (6 vs. 3 days) (7).

Frailty is characterized by a decline in physiological reserve and function across multiple organ systems, making patients more susceptible to the stresses of critical illness. This study's higher SOFA scores in frail patients (median 8.21 vs. 3) reflect greater organ dysfunction, which is consistent with the literature. The significantly higher mortality in frail patients further underscores the importance of assessing frailty in clinical practice (7). C-reactive protein (CRP) is a well-established marker of systemic inflammation. Elevated CRP levels are associated with worse outcomes in various conditions, including sepsis, cardiovascular diseases, and critical illness. The significantly higher CRP levels in frail patients (51.200 mg/dl vs. 16.905 mg/dl) and deceased patients (99.675 mg/dl vs. 32.160 mg/dl) in this study align with previous research that links elevated CRP with increased morbidity and mortality (8).

Chronic inflammation is a common feature in frail individuals and contributes to their increased vulnerability to acute stressors. Studies have shown that frailty is associated with higher levels of pro-inflammatory cytokines, which can exacerbate organ dysfunction during critical illness. The current study supports this by highlighting the correlation between higher CRP levels and frailty (9).

The trends toward higher urea and creatinine levels in frail patients and significantly higher levels in deceased patients indicate worse renal function, which is a common finding in

critically ill patients with poor outcomes. Renal dysfunction can be both a cause and a consequence of severe illness, leading to a vicious cycle of worsening organ function and increased mortality risk (10).

Elevated lactate levels are a marker of tissue hypoperfusion and metabolic stress. The significantly higher lactate levels in deceased patients (3.700 mg/dl vs. 1.200 mg/dl) in this study are consistent with previous research that links hyperlactatemia with increased mortality in critically ill patients. This underscores the importance of monitoring lactate levels as part of the prognostic assessment (11)

The Sequential Organ Failure Assessment (SOFA) score is widely used to assess the severity of organ dysfunction in critically ill patients. Higher SOFA scores are associated with increased mortality, as confirmed by this study (median SOFA score of 12 in deceased patients vs. 5 in survivors). This finding is consistent with numerous studies that validate the SOFA score as a reliable predictor of outcomes in critical care (12).

The Clinical Frailty Scale (CFS) is an effective tool for assessing frailty and its impact on patient outcomes. The significantly higher CFS scores in frail patients (median 7.5 vs. 4) and deceased patients (median 9 vs. 6) highlight the scale's utility in identifying high-risk patients. Previous research has demonstrated that higher CFS scores correlate with increased mortality, prolonged hospital stays, and greater resource utilization in critical care settings (13).

Combining frailty assessments (CFS) with severity of illness scores (SOFA) provides a comprehensive approach to risk stratification in critically ill patients. This study's logistic regression analysis identified SOFA scores >9.5 and CFS scores >7.5 as significant predictors of mortality, emphasizing the importance of using both tools in clinical practice (12, 13)

Developing prognostic models that incorporate frailty, inflammatory markers, and severity of illness scores can enhance the accuracy of outcome predictions. Such models can guide clinical decision-making, resource allocation, and individualized patient management, ultimately improving outcomes for critically ill patients (7-13).

Conclusion:

The findings of this study reinforce the importance of assessing frailty and inflammatory markers in critically ill patients. Higher frailty scores are associated with worse outcomes, including increased mortality and prolonged hospital stays. Integrating these factors with traditional severity of illness scores (such as SOFA) provides a robust framework for predicting patient outcomes and guiding clinical management. This study adds to the growing body of evidence that frailty and inflammation are crucial determinants of prognosis in critical care, underscoring the need for comprehensive and individualized approaches to patient care. The study is limited by the low number of patients (50) and the study being observational in nature.

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