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A COMPARATIVE ANALYSIS OF THE FOUR SCORE VERSUS THE GCS SCALE IN PREDICTING OUTCOMES IN CRITICALLY-ILL PATIENTS IN AN INTENSIVE CARE UNIT IN PAKISTAN

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ABSTRACT

Background: Timely and accurate neurological evaluation is crucial for intubated patients in the intensive care unit (ICU). Use of the GCS scale is standard across ICUs, although it has several limitations. Scoring systems such as Full Outline of Unresponsiveness (FOUR) can also be used to assess intubated patients. We perform a study comparing the accuracy of the FOUR score versus the GCS scale in predicting likelihood of successful extubation, and other clinical outcomes, in critically-ill patients at a tertiary care hospital in Pakistan.

Objective: This study aims to compare the accuracy of FOUR score versus the GCS scale (when administered by non-neurologist ICU clinicians) for predicting extubation success, ICU length of stay (ICU-LOS), and other clinical outcomes.

Methods: This study was conducted in a prospective cohort study design at the Aga Khan University Hospital, Pakistan (September 2024 to April 2025). We enrolled adults (over 18 years) who were intubated, and in the ICU. GCS and FOUR scores were recorded by ICU fellows, consultants, and trained nurses at the 'time of admission' and 'prior to extubation'. Patients on neuromuscular blockade were excluded. Demographic data, comorbidities, ICU-LOS, and extubation success (defined as no reintubation for 48-72 hours) were recorded. Statistical analysis was performed using chi-

square test, t-test, correlation coefficients, and receiver operating characteristic (ROC) curves.
Results: The study enrolled 160 patients, 66.9% of whom were male, average age of 51.1 ± 17.3 years. Extubation success rate was 92.5%. Diagnostic accuracy of the 'pre-extubation FOUR score' versus 'GCS scale' were marginally different and not statistically significant (AUC = 0.63 vs 0.59, $p > 0.05$). Both FOUR and GCS had a high positive predictive value (PPV), 94.7% and 94.0%, respectively, but a low negative predictive value (NPV); 12.8% and GCS: 11.6%, respectively. Patients with extubation failure had significantly shorter ICU-LOS.
Conclusion: Both FOUR and GCS scoring systems provided predictive accuracy for extubation success, with slightly better performance for the FOUR score. Both scoring systems provided weak predictive value for failure. The use of the FOUR score can augment the neurological assessment of ICU patients, especially in units with limited neurology resources and high patient volumes.

INTRODUCTION

Accurate neurological assessment of a critically-ill patient is crucial to achieving successful extubation and good clinical outcomes in the intensive care unit (ICU). Accurate assessment can be challenging for several different reasons; a) acute neurological change is often overt and difficult to detect due to a sedated and intubated (non-verbal) status, b) patients are susceptible to sudden catastrophic deterioration, (i.e., thrombocytopenia or coagulopathy leading to an intracranial bleed), and c) there is a high degree of variability in the training experience of healthcare providers working in ICUs (nurses, technicians, aids, trainees, non-neurologist clinicians, and neurologist clinicians) who can accurately detect this neurological change.

Multiple scoring systems to assess neurological status are used in clinical practice. The Glasgow Coma Scale (GCS) is the most widely used and assesses verbal, motor, and ocular responses. It is relatively easy to administer and has prognostic value in several conditions such as traumatic brain injury (TBI), subarachnoid hemorrhage (SAH), and acute bacterial meningitis (ABM) (1-4). The GCS scale however, is of limited utility in intubated (non-verbal) patients, does not assess brainstem reflexes and has a high inter-observer variability (4).

The Glasgow Coma Scale (GCS) has been evaluated as a tool for predicting patient outcomes following central nervous system (CNS) injury, though its predictive strength appears limited. When administered at 24- and 72 hours post-injury, the GCS was a weak predictor of in-hospital mortality, with odds ratios of 0.4 and 0.59 (4), respectively. This suggests a limited ability to distinguish between patients who will survive and those who will not during the hospital stay. In terms of predicting post-injury functional independence, the GCS demonstrated a moderate overall accuracy of 71%. However, its correlation with more comprehensive functional outcome measures was modest—showing a negative correlation of -0.28 with the Disability Rating Scale and a positive correlation of 0.37 with the cognitive component of the Functional Independence Measure (5). These findings indicate that while the GCS provides some prognostic value, it may not fully capture the complexity of neurological recovery or long-term functional outcomes.

Comparisons with the FOUR score have also been performed. A study conducted in Lahore, Pakistan in 2017, assessing the predictive accuracy of FOUR score versus GCS showed that the FOUR score's had a sensitivity of 63.46%, specificity of 86.44%, positive predictive value of 67.35%, negative predictive value of 84.30%, and an accuracy rate of 79.41% for predicting poor outcomes amongst children admitted to the pediatric ICU. In comparison, the GCS score had a sensitivity of 55.76%, specificity of 83.89%, positive predictive value (PPV) of 60.42%, negative predictive value (NPV) of 81.15%, and an accuracy rate of 75.29% for the same outcome. In this study, the FOUR score performed better than the GCS across all evaluated metrics, including sensitivity, specificity, and PPV, NPV, and overall accuracy. While the differences between the two scores were not dramatic, they were consistently in favor of the FOUR score. Notably, the FOUR score demonstrated higher sensitivity, indicating a better ability to identify those at risk for poor outcomes, and a higher NPV, suggesting greater reliability when predicting favorable outcomes. In the context of the pediatric ICU setting in Lahore, these findings suggest that the FOUR score is a slightly more accurate and reliable tool than the GCS for predicting poor outcomes in critically ill children (6).

Another prospective study conducted in a tertiary care hospital of South Malabar, 2024, reported predictive mortality among patients with traumatic brain injury (TBI). 85.7% of the 21 non-survivors had a GCS < 5 and FOUR score < 4. GCS mortality sensitivity, specificity, PPV, and NPV were 85.71%, 93.02%, 75, and 96.4, respectively ($p < 0.0001$). FOUR score mortality sensitivity, specificity, PPV, and NPV were 85.71%, 96.51%, 85.7%, and 96.5%, respectively ($p < 0.0001$) (7).

Hence, clinicians have sought to develop scoring systems that address key components of neurological health that were not part of the original GCS. Wijdicks et al. at the neurocritical care unit at Mayo Clinic developed the 'Full Outline of Unresponsiveness (FOUR) score'; a 17-point scale (with potential scores ranging from 0 - 16) that assesses the four domains of neurological function: eye response, motor response, brainstem reflex, and breathing pattern. Decreasing FOUR score is associated with worsening level of consciousness (3).

This score is shown to have good interrater reliability and accurately predicts outcomes after TBI (8, 9) and for patients in the neurological/neurosurgical intensive care unit (10). In 2019, a systematic review exploring the relationship of the FOUR score to outcomes in adult patients with impaired consciousness was performed (CENTRAL, MEDLINE, EMBASE, Scopus, Web of Science, ClinicalTrials.gov, and OpenGrey). Prospective, observational studies were carried out on patients with impaired consciousness to study mortality and functional outcome scores. All prospective, observational studies and randomized, controlled trials published between 2005 and 2018 were included. This review however focused on patients with a neurological diagnosis, intubated patients, and those admitted to dedicated neuroscience centers (9). Despite of significant heterogeneity in patient characteristics in the analysis, FOUR score showed good to excellent prognostication of in-hospital mortality in most studies (area under curve [AUC], >0.80). It was good at predicting poor functional outcome (AUC, 0.80-0.90). There was some evidence that motor and eye components (also GCS components) had better prognostic ability than brainstem components. The overall conclusion from the analysis was that the FOUR score relates closely to in-hospital mortality and poor functional outcome.

Since then, the scoring system has been further assessed in other settings where neurological complications arise, such as the medical ICU and emergency department (ED). Even without specific neurological training, the inter-rater reliability remains high, allowing for consistent assessment of patients in these settings (9) for primary neurological illness such as intracerebral

hemorrhage, subarachnoid hemorrhage, neurodegenerative disease, drowning, cardiac arrest, ethanol poisoning, and tubercular meningitis. It has also been studied and validated for application by ICU nurses who have limited experience (11).

In summary, while the GCS remains the most commonly administered score both within and outside of the hospital – it has significant limitations due to reliance on verbal responses. The FOUR score eliminates this confounding factor and adds objective information from a basic neurological coma examination standpoint that provides prognostic and clinical information to help guide management. Despite its encouraging results, the FOUR score is still not well-known, or widely utilized in ICUs and little known about its inter-rater reliability when administered in low-middle income countries (LMICs).

METHODS AND MATERIALS

Inclusion Criteria

All adult patients (above 18 years of age) who were intubated and admitted to either the medical or the surgical ICU of the Aga Khan University Hospital from September 2024 to April 2025 were included in this prospective study.

Patients with a primary neurological diagnosis and those with a primary non-neurological diagnosis were included (regardless of baseline GCS).

Baseline GCS and FOUR score was recorded for all patients. Scoring was performed independently by the on-duty critical care fellow, ICU consultant and / or ICU nurse. Measurements on admission were followed by a final score just prior to a decision to extubate – were recorded. Patients receiving sedation or neuromuscular blockade were excluded.

Demographics (age, gender etc.), clinical history relevant to medical illness, mental status, and co-morbid conditions were recorded. Neuroimaging (cranial MR, CT, or MR/CT angiography (MRA/CTA)) as available during hospitalization were recorded. Pertinent clinical details surrounding extubation decisions and laboratory parameters were also recorded.

Extubation success (no re-intubation within 48-72hours of extubation), duration of ICU stay, and total length of in-hospital stay of all patients were recorded.

Data was recorded on google forms and stored in lock and key with access only available to the PI and team members.

Ethical considerations such as anonymity, result communication and confidentiality were prioritized. This study was approved by the Ethics Committee of AKUH (ERC Approval # 2024-10341-30906) and carried out in accordance with expected ethical standards. Informed consent was exempt (neurological assessment is part of routine examination in the ICU).

Exclusion Criteria

All patients < 18 years of age were excluded.

Patients receiving neuromuscular blockade were excluded.

OUTCOMES

Primary Outcome

The FOUR score will be compared to the GCS in predicting:

(1) Extubation success (defined as ‘no reintubation within 48-72 hours of extubation’).

Secondary Outcome(s)

(1) Effect on overall ICU length of stay, and hospital length of stay.

Statistical Analysis

Statistical analysis included descriptive statistics to summarize demographic and clinical variables. Comparative analyses were performed using the Chi-square test for categorical data and Student's t-test for continuous variables. Spearman correlation coefficients were calculated to assess associations between the neurological scores and clinical outcomes. Receiver Operating Characteristic (ROC) curve analysis was conducted to evaluate the predictive accuracy of the GCS and FOUR scores by determining the area under the curve (AUC). A significance threshold of $p < 0.05$ was applied for all statistical tests. The study included a sample size of 160 patients.

RESULTS

A total of 160 patients were enrolled in the study, with a mean age of 51.1 ± 17.3 years, indicating a middle-aged population with a wide age distribution (Tab 1.). The majority of participants were male (66.9%), while females constituted 33.1% of the cohort. Hypertension was the most prevalent comorbidity, present in 46.9% of patients, followed by diabetes mellitus in 30.0%, and coronary artery disease (CAD) in 15.0%. Regarding the primary admitting diagnosis, 43.1% of patients were admitted with neurological conditions, whereas 56.9% had non-neurological diagnoses, reflecting a diverse ICU case mix. Patients were nearly evenly distributed between medical (55.0%) and surgical (45.0%) intensive care units, suggesting balanced representation across different ICU settings.

Among 160 critically ill, intubated patients, the mean Glasgow Coma Scale (GCS) score on ICU admission was 9.74 ± 4.59, while the mean Full Outline of Unresponsiveness (FOUR) score was 12.2 ± 3.45, indicating moderate neurological impairment at baseline. Prior to extubation, both scores showed improvement, with mean GCS rising to 9.54 ± 0.96 and FOUR to 12.4 ± 1.15, reflecting recovery of neurological function over the ICU stay (Tab 3.).

The average ICU length of stay (LOS) was 4.13 ± 2.02 days, while the mean in-hospital LOS was 11.3 ± 6.89 days. Extubation success was achieved in 92.5% of patients (n = 148), with only 7.5% (n = 12) requiring re-intubation.

The diagnostic accuracy of pre-extubation FOUR score was slightly superior to the GCS scale (Fig 2.), (AUC 0.63 v/s 0.59, respectively), ($p > 0.05$). Both FOUR score and GCS scale had a high positive predictive value (PPV); 94.7% and 94.0%, respectively, and a low negative predictive value (NPV); 12.8% and 11.6%, respectively. Patients with extubation failure had significantly shorter ICU length of stay (LOS), ($p < 0.001$). The marginal improvement in pre-extubation FOUR and GCS scores indicates both tools effectively captured neurological progress, though the FOUR score demonstrated slightly greater sensitivity in detecting changes among intubated patients. The high extubation success rate, coupled with relatively short ICU stays, suggests that both scoring systems were reliable for guiding extubation readiness.

Fig 1. Depicts a strong positive correlation was observed between FOUR and GCS scores at both time points. On admission, the Spearman's rho was 0.92 (95% CI: 0.89–0.95, $p < 0.001$), indicating excellent concordance between the two scales. Pre-extubation, the correlation remained strong at 0.79 (95% CI: 0.68–0.88, $p < 0.001$), demonstrating consistent agreement in neurological assessment closer to extubation.

In Fig 3. Spearman's correlation analysis showed a weak but statistically significant negative correlation between FOUR score and hospital length of stay (LOS) ($\rho = -0.16$, $p = 0.049$),

indicating better neurological status was associated with shorter hospitalization. The GCS exhibited a similar, non-significant trend ($\rho = -0.13$, $p = 0.102$). Neither FOUR nor GCS scores correlated significantly with ICU LOS (FOUR: $\rho = -0.12$, $p = 0.117$; GCS: $\rho = -0.08$, $p = 0.296$), suggesting limited predictive value for ICU stay duration.

DISCUSSION

Our study compares the prognostic value of the FOUR score versus the GCS scale amongst critically-ill, intubated patients admitted to a tertiary care facility in Pakistan. This study had several unique aspects. First, it is one of the few studies performed comparing the two scores in a low-middle income setting such as Pakistan. Few prior studies have compared GCS vs FOUR scoring systems on mortality and outcomes in such as setting – one notably conducted at the Jinnah Postgraduate Medical Centre, Karachi, comparing the performance of the two scores amongst trauma patients in the Emergency Department (ED). This was a key strength of this study addressing a significant gap in the current literature that is largely dominated by data from high-resource settings. Second, our study was unique in that it included assessment by personnel who were not always neurology subspecialty trained or had minimal to no specific training in dedicated neurological assessment in the ICU. To our knowledge, no other studies have emphasized this unique aspect in the administration of these clinical scoring systems. The inclusion of assessments performed by healthcare personnel with varying levels of neurological training enhances the generalizability of the findings to real-world clinical environments. The addition of brainstem reflexes to the FOUR score and its validity when utilized by non-neurologists make it especially useful in resource-limited setups, where expert neurological input requiring investigations may be limited.

Third, our study has several important statistical findings. We find that the FOUR score was slightly more accurate in predicting ‘extubation success’ (AUC 0.63) than the GCS (AUC 0.59), albeit this result was not statistically significant. This finding is consistent with prior literature that highlights the benefits of the FOUR score, particularly in intubated patients when the verbal component of the GCS cannot be ascertained. Wijdicks (10) first developed the FOUR score incorporating brainstem reflex and respiratory pattern evaluation, making it more appropriate to this non-verbal, neurologically compromised patient population. Other authors, such as Said et al (12) have also described the FOUR score's higher accuracy in predicting extubation success, noting that its incorporation of brainstem reflexes and respiratory patterns, key components that are assessable in intubated patients, allows for a more comprehensive neurological evaluation compared to the GCS, which relies on a verbal response that cannot be elicited in these patients.

Next, we find that the two instruments have a high PPV for successful extubation and corroborate prior work that also show the value of these scales in predicting good outcomes (12). Their low NPV for ‘extubation failure’ suggest that they are of limited use in predicting extubation failure when used alone. To further explain, the GCS and FOUR score can be useful at the bedside for identifying patients who are likely to succeed in extubation. A high PPV indicates that when a patient has a good score on either scale, clinicians can be reasonably confident that the patient will tolerate extubation and breathe effectively without re-intubation. In practice, this supports the use of these tools to help reinforce decisions to proceed with extubation, especially when the clinical picture is otherwise favorable. However, the low NPV means that a poor score on these tools does not reliably predict extubation failure. So, if a patient has a low GCS or FOUR score, it doesn’t necessarily mean they will fail extubation—many may still do well. Therefore, these scores should not be used in isolation to delay or deny extubation,

especially if other clinical signs (such as adequate respiratory effort, airway protection, and gas exchange) are reassuring.

Our findings align with existing evidence indicating that a GCS score of 10 or less is strongly associated with extubation failure, whereas a GCS score of 8 or more is linked to successful extubation (in approximately 75% of cases) compared to only 33% in those with scores lower than 8 (13). Additionally, Mokhlesi et al. report that patients with moderate GCS scores (of 9–12) are at increased risk of re-intubation, suggesting this group remains vulnerable (14). These observations highlight the continued clinical relevance of the GCS in predicting extubation outcomes, despite its known limitations in intubated patients, and the need to further develop and bolster clinical scoring systems to improve their predictive accuracy.

While GCS and FOUR scores can support decisions to extubate in patients with favorable scores, they are not sufficient on their own to withhold extubation in patients with lower scores. Clinical judgment and a comprehensive assessment of respiratory, neurological, and airway parameters remain essential. Other predictors of extubation failure in neurocritically-ill patients include a low motor component of GCS, female sex, longer duration of mechanical ventilation, and secretion volume (15).

The study has several limitations. A) this study was conducted at only one site with a small sample size which makes it difficult to generalize the study to other clinical settings. Patients receiving neuromuscular blockade were excluded and this may reduce the study result generalizability to these patients who are often some of the most critically-ill patients. B) Assembling assessors of differing neurologic expertise does enhance external validity but it may also have contributed to scoring variability which may have affected how precise the recorded assessments were. C) This was an observational study meaning that the scoring systems used and outcomes at the time of extubation cannot be causally related. Finally, the predictive analyses may lack precision as factors that affect extubation outcomes, such as sedation, comorbidities, and days of mechanical ventilation were not controlled.

CONCLUSION

We can conclude from this study that while GCS and FOUR scores can support decisions to extubate in patients with favorable scores, they are not sufficient on their own to withhold extubation in patients with lower scores. Clinical judgment and a comprehensive assessment of respiratory, neurological, and airway parameters remain essential. A larger study population in future studies should be conducted to evaluate if significant changes by implementation of FOUR score can predict promising outcomes of extubation.

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APPENDIX

Table 1: Baseline demographics of all patients

Variable	Total patients (N = 160) (n (%))
Age	
Mean	51.1 (17.3%)
Gender	
Male	107 (66.9%)
Female	53 (33.1%)
Hypertension	
Yes	75 (46.9%)
No	85 (53.1%)

Diabetes Mellitus	
Yes	48 (30.0%)
No	112 (70.0%)
Coronary artery disease (CAD)	
Yes	24 (15.0%)
No	136 (85.0%)
Admitting Diagnosis	
Neurological	69 (43.1%)
Non-neurological	91 (56.9%)
Intensive care unit (ICU)	
Medical	88 (55.0%)
Surgical	72 (45.0%)

Table 2: Laboratory serum parameters (just prior to extubation)

Variable	Total patients (N=160)
BUN	21.0 (11.0, 36.3)
Ammonia	67.0 (45.0, 76.0)
Not checked in others	143 (89.4%)
Ionized Calcium	4.40 (4.21, 4.54)
Glucose	122 (99.0, 146)
Sodium	141 (139, 145)
Total Bilirubin	2.10 (0.800, 3.70)
Procalcitonin	1.65 (0.450, 3.16)
C-Reactive Protein	124 (74.1, 165)

Table 3: Comparison of outcomes when the GCS is used versus the FOUR score

Variable	Overall (N=160)
GCS on Admission	
Mean (SD)	9.74 (4.59)
GCS Pre-Extubation	
Mean (SD)	9.54 (0.964)
FOUR on Admission	
Mean (SD)	12.2 (3.45)
FOUR Pre-Extubation	
Mean (SD)	12.4 (1.15)
ICU LOS	
Mean (SD)	4.13 (2.02)
In-Hospital LOS	
Mean (SD)	11.3 (6.89)
Extubation Success	

Yes	148 (92.5%)
No	12 (7.5%)

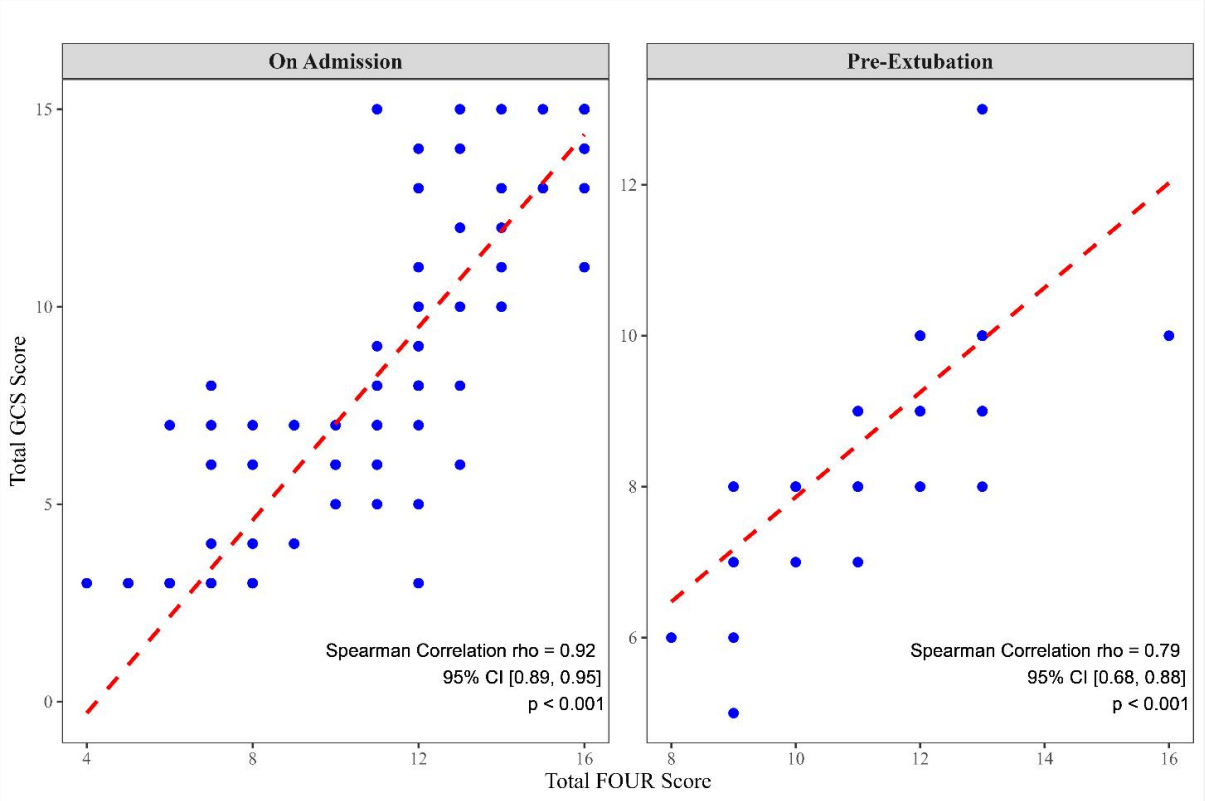

Figure 1: Spearman Correlations of FOUR and GCS Scores on admission and Pre extubating time

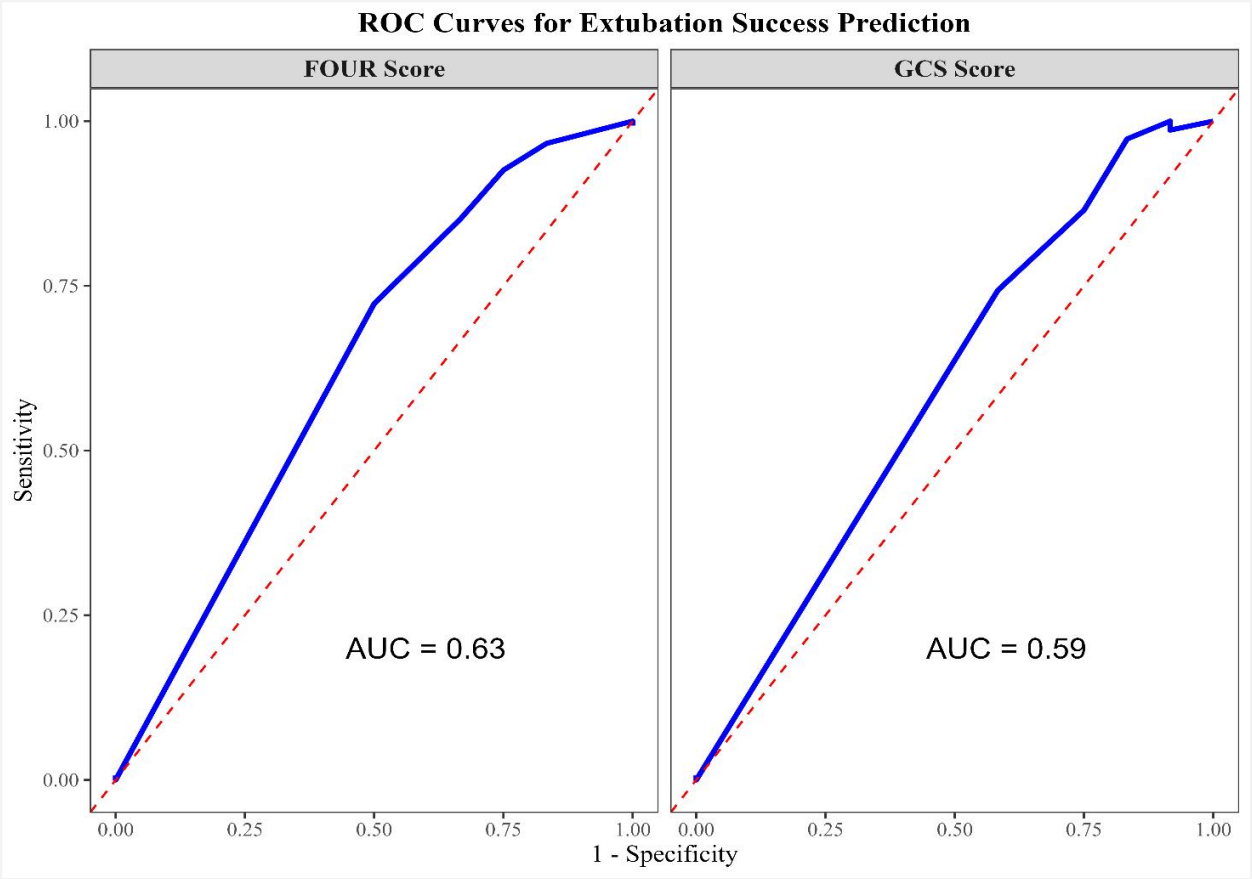

Figure 2: Receiver operator characteristic curves for FOUR and GCS scores

Table 4: Diagnostic Values of GCS and FOUR Score for Predicting Extubation Success

Diagnostic Metrics	GCS Score	FOUR Score
Sensitivity (%)	74.32	72.3
Specificity (%)	41.67	50
Positive Predictive Value (%)	94.02	94.69
Negative Predictive Value (%)	11.63	12.77
95% CI (AUC)	0.43 to 0.75	0.47 to 0.79
AUC	0.59	0.63
P-value	> 0.05	> 0.05

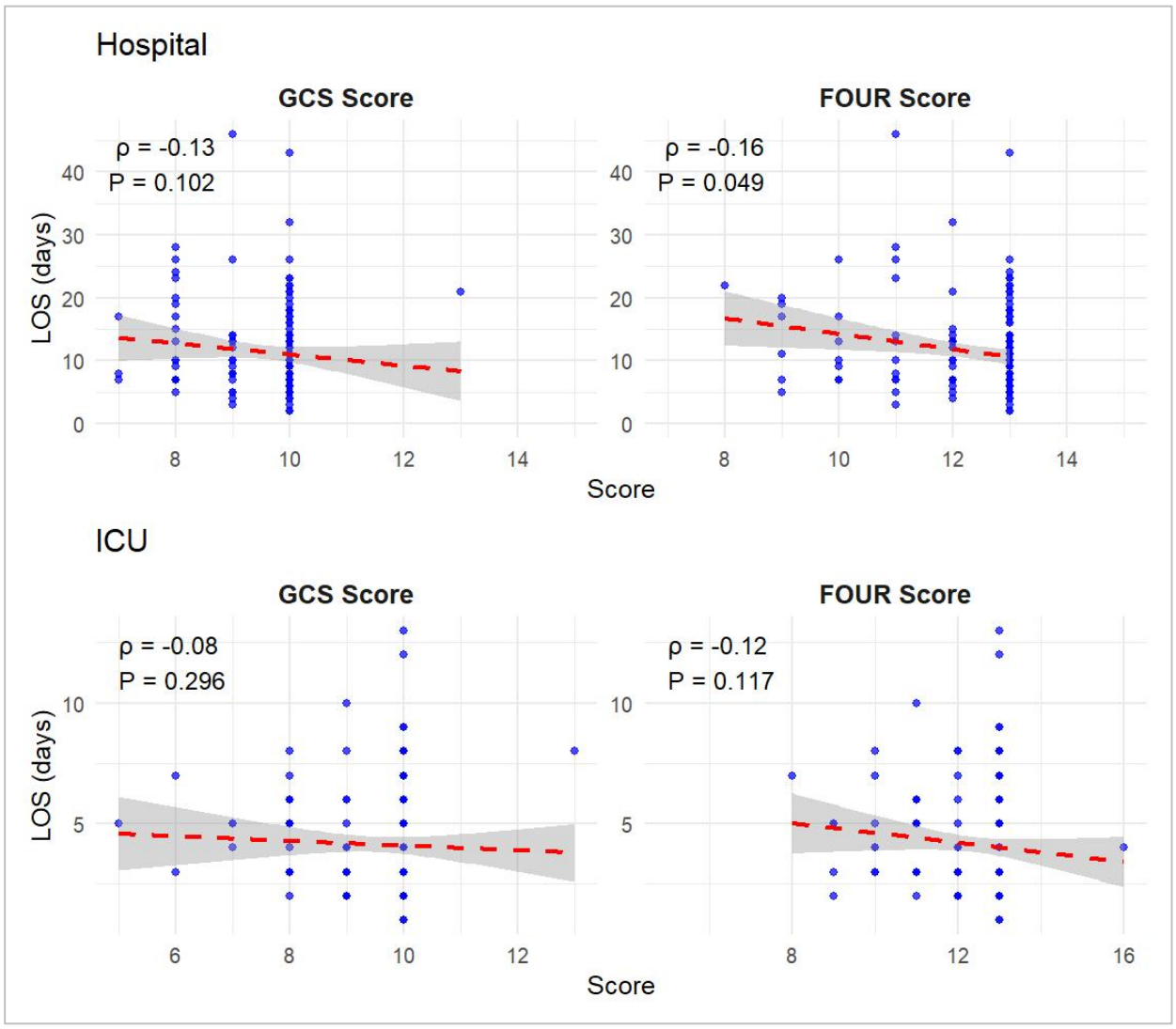

Figure 3: Spearman Correlations of FOUR and GCS Scores with Hospital and ICU Length of Stay

Table 5: Comparison of Patient Characteristics and Extubation Outcome and Length of Stay

Extubation	Failure	Success
	(N=12)	(N=148)
Admitting Diagnosis		
Neurological	5 (41.7%)	64 (43.2%)
Non-neurological diagnosis	7 (58.3%)	84 (56.8%)
Surgical/non-surgical		
Medical	10 (83.3%)	78 (52.7%)

Surgical	2 (16.7%)	70 (47.3%)
LOS	**ICU**	**Hospital**
Surgical/Medical		
Medical	4.0 [3.0, 6.0]	11.0 [7.0, 14.0]
Surgical	3.0 [2.0, 4.0]	8.0 [6.0, 12.3]
P-value	<0.001	0.014
Admitting Diagnosis		
Neurological	3.0 [3.0, 5.0]	10.0 [7.0, 13.0]
Non-neurological diagnosis	4.0 [3.0, 5.0]	10.0 [7.0, 14.5]
P-value	0.2226	0.531