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ASSOCIATION OF AGE AND FOUR SCORE WITH ICU LENGTH OF STAY IN POST-CRANIOTOMY PATIENTS AT SAKINAH HOSPITAL MOJOKERTO

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ABSTRACT

This study aimed to analyze the association factors between age, FOUR Score, and ICU length of stay among post-craniotomy patients treated at Sakinah Hospital. A cross-sectional study was conducted from 01 October to 12 December 2025 involving adult post-craniotomy patients admitted consecutively to the ICU. Eligible participants were ≥18 years old, intubated postoperatively, and had a completed FOUR Score assessment. Fisher's Exact Test and relative risk (RR) with 95% confidence intervals (CI) were applied to examine associations between age, FOUR Score, and ICU LOS. A significance level of $p < 0.05$ was used. 29 patients, 58.6% were aged ≥53 years and 62.1% experienced prolonged ICU stay. A FOUR Score ≤10 was observed in 58.6% of the cohort. Lower FOUR Scores were strongly associated with prolonged ICU stay ($p < 0.000$; RR = 9.7; 95% CI: 1.4–63.8). Older age also demonstrated a significant association with extended LOS ($p = 0.018$; RR = 2.47; 95% CI: 1–7.7). Both advanced age and lower FOUR Scores were significant associated with prolonged ICU stay among post-craniotomy patients. These findings underscore the utility of integrating neurological scoring with demographic risk profiling to support early prognostication and guide resource allocation in neurosurgical critical care.

Keywords

FOUR Score;age;length of stay, post-craniotomy

INTRODUCTION

Craniotomy is a fundamental surgical procedure for various intracranial conditions, such as traumatic brain injury, brain tumors, and vascular malformations (Lonjaret et al., 2017).

Despite improvements in surgical and perioperative care, patients who undergo craniotomy remain at significant risk for neurological deterioration, making close monitoring in the intensive care unit (ICU) essential to optimize outcomes and reduce morbidity and mortality (Kurz et al., 2025). The clinical profile and prognosis of these patients are shaped by multiple factors, including age, underlying pathology, comorbidities, and the complexity of the surgical procedure, all of which can influence the length of ICU stay and overall recovery (Dasenbrock et al., 2015).

Accurate and timely neurological assessment in the ICU is crucial for early

detection of complications such as cerebral edema, hemorrhage, seizures, and delayed awakening. The Glasgow Coma Scale (GCS) has long been the standard tool for evaluating consciousness in neurocritical care, but it has notable limitations, especially in intubated or sedated patients, as it may not fully capture the spectrum of neurological function (Agrawal et al., 2023a).

To address these limitations, the Full Outline of UnResponsiveness (FOUR) Score was developed, incorporating four domains : eye response, motor response, brainstem reflexes, and respiration, allowing more comprehensive assessment, particularly in patients who are intubated or have impaired verbal responses (Raaj Vishnu R et al., 2023).

Recent studies and systematic reviews have shown that the FOUR Score provides prognostic value comparable to or slightly better than the GCS in various neurocritical populations, including those with traumatic brain injury and post-neurosurgical states. Both tools demonstrate good to excellent accuracy in predicting mortality, with area under the curve (AUC) values often above 0,87 and both are associated with ICU length of stay and functional outcomes (Schey et al., 2025).

The FOUR Score capabilities to assess brainstem reflexes and respiratory patterns is particularly advantageous in the ICU, where many post-craniotomy patients require mechanical ventilation (Khanal et al., 2016). However, there is still limited data specifically characterizing the clinical profile of post-craniotomy patients in the ICU as assessed by the FOUR Score, especially across different healthcare settings and age groups (Suresh et al., 2019). Age is a well-established determinant of outcomes in neurocritical care, with older patients generally experiencing longer ICU stays, higher complication rates, and poor functional recovery following craniotomy (Sangtongjaraskul et al., 2023).

The relationship between age, neurological status as measured by the FOUR Score (Nyam et al., 2017), and ICU length of stay represents an important area for further research to inform risk stratification and optimize resource allocation in neurocritical care settings (Sangtongjaraskul et al., 2023).

Despite growing evidence supporting the prognostic utility of the FOUR Score in diverse neurocritical care populations, several important gaps remain in the current literature. Most existing studies have focused on heterogeneous cohorts, such as traumatic brain injury or mixed neurosurgical patients, with outcomes primarily centered on mortality or short-term neurological status rather than ICU length of stay as a clinically meaningful resource-related outcome (Nyam et al., 2017 ; Schey et al., 2025). Consequently, data specifically examining post-craniotomy patients, a group with distinct perioperative risks and recovery trajectories remain limited.

Furthermore, although age has consistently been identified as a key determinant of adverse outcomes and prolonged ICU hospitalization after neurosurgical procedures, few studies have explored the combined relationship between age, level of consciousness as measured by the FOUR Score, and ICU length of stay within a single analytical framework (Sangtongjaraskul et al., 2023). Prior research has often evaluated these variables in isolation, thereby limiting their applicability for comprehensive risk stratification and early prognostic assessment in routine ICU practice.

Additionally, understanding the distribution of clinical characteristics, such as primary diagnosis, comorbidities, and perioperative are factors among post-craniotomy patients, can provide valuable insights for ICU management protocols and improving patient outcomes (Kurz et al., 2025).

The aim of cross-sectional study to identify patterns and associations among patient age, FOUR Score, and length of ICU on post-craniotomy patients admitted to the ICU at Sakinah Hospital. Given the increasing global burden of neurosurgical diseases and the growing demand for critical care resources, there is a pressing need for robust, context-specific data on the clinical trajectories of post-craniotomy patients in the ICU. Cross sectional studies are vital for

elucidating these patterns, identifying gaps in care, and guiding future interventional research. By systematically profiling post-craniotomy patients using the FOUR Score, research can contribute to the evidence base supporting optimal neurocritical care practices and highlight key factors were associated with ICU length of stay and patient outcomes.

METHOD

The type of research used is a cross-sectional survey. The study was conducted at the Sakinah Hospital in October–December 2025. The research population is adult patients who underwent craniotomy and were admitted to the ICU during the study period. A consecutive sampling approach was employed, including all eligible patients who met the inclusion criteria. Inclusion criteria are aged ≥ 18 years, intubated, admitted to the ICU after surgery, completed neurological assesement using FOUR Score. The variables in this study were FOUR Score and age as independent variables, ICU length of stay as dependent variables. The instrument uses an assesement tools Full Outline UnResponsiveness (FOUR). Data were analyzed using SPSS version 21 (IBM Corp, Armonk, NY). Descriptive statistics were applied to summarize patient characteristics. Categorical variables were presented as frequencies and percentages. ROC curve analysis revealed that age ≥53 years (AUC = 0.72; 95% CI: 0.60–0.84), FOUR Score ≤10 (AUC = 0.79; 95% CI: 0.68–0.90), and ICU length of stay ≥3 days (AUC = 0.81; 95% CI: 0.70–0.92) provided optimal sensitivity and specificity for identifying patients at risk of prolonged ICU stay following craniotomy. These findings indicate acceptable to good discriminatory power of the proposed thresholds.

Bivariate analysis using Fisher's exact test (as appropriate) with Relative Risk was employed to examine associations between independent variables (FOUR Score, Age) and ICU LOS. Variables with $p < 0.25$ in bivariate analysis to estimate Relative ratios (RR) and 95% confidence intervals (CI). Statistical significance was set at $p < 0.05$.

RESULTS

Table 1. Respondents' Frequency Distribution Based on FOUR Score, Age and Length of stay Hospital.

Variabels	F	%
FOUR Score value		
≤ 10	17	58,6
> 10	12	41,4
Age		
≥ 53 years	17	58,6
< 53 years	12	41,4
Length of stay		
Long stay	18	62,1
Short stay	11	37,9

Based on the table 1, the majority of post-craniotomy patients admitted to the ICU of Sakinah Hospital, 58,6% were aged more than 53 years old, while younger than 53 years accounted for 41,4%. Most patients experienced a prolonged ICU stay, representing 62,1%, whereas 37,9% patients with a shorter length of stay. Regarding the FOUR Score, 58,6% of patients had a score ≤10, while 41,4% had a score > 10.

Table 2. Crosstabulation of FOUR Score and Age on Length of stay among post-craniotomy patients at ICU at Sakinah Hospital

Variabels	Length of stay				*p-value and Relative risk*
	Long stay		Short stay		
	f	%	F	%	
FOUR Score					
≤ 10	16	94	1	6	*p-value* =0,000 RR = 9,7; 95% CI (1,4 – 63,8)
> 10	2	17	10	83	
Age					
≥ 53 years	14	82	3	18	*p-value* = 0,018 RR = 2,47; 95%CI (1–7,7)
< 53 years	4	33	8	67	

Fisher's Exact Test showed that length of stay was significantly associated with both FOUR Score value (p = 0,000) and length of stay (p = 0,018). Patients with lower FOUR Scores were nearly 10 times more likely to experience prolonged ICU stay (RR = 9,7; 95% CI: 1.4–63,8) and required a longer age (RR= 2,47; 95% CI: 1–7,7).

DISCUSSION

Association Between Age and Length of stay

The predominance of patients older than 53 years (58.6%) in the post-craniotomy ICU has important clinical and organizational implications and aligns with contemporary series showing shifting age demographics and outcome gradients after craniotomy. The observed association of older age with extended stay from Fisher's Exact test showed (p = 0.018; RR = 2.47; 95% CI: 1–7.7) that indicates a moderate increased risk of age to prolonged stay.

This directionally consistent with literature that finds, older patients often experience more complicated courses and prolonged recovery times, although direct effect estimates for age on length of stay are less commonly reported in focused studies at FOUR Score (Ramazani & Hosseini, 2022). Large prospective data have documented that elderly craniotomy patients have longer postoperative hospital and intensive care stays and are less likely to be discharged directly home, indicating greater postoperative dependency and resource needs (Hessington et al., 2018).

However, the association between chronological age and ICU LOS is not strictly linear and may vary by case mix and healthcare context. Several studies have reported that younger age groups can show prolonged ICU admission in specific populations, often reflecting different admission thresholds, more aggressive life-sustaining treatment, or complications tied to the underlying pathology rather than age. Thus, crude comparisons that treat age as the sole driver of prolonged stay risk oversimplifying a complex relationship shaped by diagnosis, surgical complexity, and institutional practices. This heterogeneity highlights why unadjusted analyses can be misleading and why multivariable models that include clinical severity, procedure type, and discharge disposition are essential (Rodrigues et al., 2024).

In intracerebral hemorrhage and other neurosurgical cohorts, older age has been repeatedly associated with higher early mortality and with longer neurocritical care admissions, supporting age as a consistent risk marker for worse short term outcomes after neurosurgical interventions (Tas et al., 2018). These convergent findings suggest that the overrepresentation of older adults at Sakinah Hospital may reflect age-related vulnerability to complications.

Age is a consistent determinant of postoperative, and its relationship with length of stay. Older age is commonly associated with longer postoperative hospital stays after neurosurgical procedures because of reduced physiologic reserve, higher prevalence of comorbidity, and increased susceptibility to complications such as pneumonia, delirium, and impaired wound healing. These age-related vulnerabilities translate into slower recovery trajectories, increased need for postoperative monitoring, and a greater probability of discharge to step-down facilities or rehabilitation, all of which extend LOS (Vallet et al., 2023).

Biological and geriatric constructs explain much of the age effect. Frailty, sarcopenia, immunosense, and malnutrition conditions that increase in prevalence with chronological age, are stronger predictors of prolonged LOS and adverse postoperative

outcomes than age alone. Including frailty or functional status measures alongside age improves predictive accuracy for prolonged ICU and hospital stays, and better identifies patients who might benefit from prehabilitation or targeted perioperative optimization. From a mechanistic viewpoint, frailty amplifies the physiologic impact of surgical stress and infection risk, increasing complication rates that directly prolong LOS (Perrella et al., 2024).

From a clinical and policy standpoint, acknowledging the complex interplay of age, frailty, and procedural factors has practical implications. Preoperative geriatric assessment and early involvement of multidisciplinary teams (geriatrics, physio/occupational therapy, nutrition) can reduce complications and may shorten LOS. For neurosurgical services, risk-stratified pathways that incorporate frailty and anticipated discharge needs enable better bed management and more efficient use of ICU resources. Cost-effectiveness assessments should consider that chronological age alone is an imperfect target interventions aimed at modifiable geriatric syndromes may yield greater reductions in LOS than those aimed solely by age thresholds (Vallet et al., 2023).

As described by Biswas et al., 2024, reflects a mix of patient factors, operative complexity, and perioperative physiology. Perioperative determinants such as intraoperative hemodynamic instability, preoperative neurologic deficits, tumor characteristics, and the need for additional support have been linked to higher rates of ICU admission and longer stays, highlighting modifiable targets for perioperative management.

System interventions can safely reduce ICU utilization for selected craniotomy patients without worsening outcomes; implementation of structured pathways has been shown to decrease ICU utilization and overall postoperative length of stay while maintaining acceptable complication and readmission rates, indicating that careful patient selection and protocols can mitigate prolonged ICU occupancy (Gopalakrishnan et al., 2018). Conversely, postoperative complications are associated with extended ICU and hospital stay and worse outcomes, emphasizing the importance of strategies to prevent early postoperative deterioration (Khalili et al., 2019).

Association Between FOUR Score and Length of stay

The observed predominance of FOUR Score ≤10 (58.6%) and Fisher's Exact test was showed statistically significant association between lower FOUR values and prolonged length of stay ($p < 0.000$; RR = 9.7; 95% CI: 1.4–63.8). The findings suggest that lower FOUR Score values are associated with an extended ICU stay. However, the notably wide confidence interval indicates a limited sample size and substantial variability within the data. Despite these constraints, this study has prognostic relevance in neurosurgical critical care and consistent with literature that validates the FOUR Score as a robust consciousness scale for outcome prediction. A comprehensive scoping review found that the FOUR Score demonstrates good interobserver reliability and has prognostic utility for mortality and functional outcomes across a range of neurologic and neurosurgical conditions, frequently performing equivalently or superiorly to the Glasgow Coma Scale by incorporating brainstem reflexes and respiratory pattern (Almojuela et al., 2019). Recent work combining Glasgow Coma Scale and FOUR elements has further linked these composite assessments with ICU length of stay, mortality, and functional endpoints in traumatic brain injury, suggesting that lower FOUR Scores correlate with greater severity

and worse trajectories in neurosurgical populations (Agrawal et al., 2023).

Clinically, the high frequency of FOUR Score ≤10 in the Sakinah sample therefore indicates a subgroup at elevated risk for adverse short-term outcomes and prolonged resource needs, routine use of the FOUR Score could improve early prognostication, guide intensity of monitoring, and inform discussions about goals of care and expected recovery (Almojuela et al., 2019).

Potential explanations for the age, prolonged stay, and FOUR Score patterns observed at Sakinah Hospital include case-mix shifts toward older and more comorbid patients, higher surgical complexity, and perioperative physiologic instability factors recurrently reported as drive of ICU use and poorer outcomes in recent studies (Ramazani & Hosseini, 2022).

CONCLUSIONS

Both advanced age and lower FOUR Scores were significant associated of prolonged ICU stay among post-craniotomy patients. These findings underscore the utility of integrating neurological scoring with demographic risk profiling to support early prognostication and guide resource allocation in neurosurgical critical care. Larger, multicenter studies are warranted to refine risk estimates and enhance generalizability.

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