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Association Between Admission-to-Surgery Time and Outcomes in Traumatic Brain Injury at RSSA

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ABSTRACT

Despite evidence that streamlined trauma protocols reduce preoperative delays and improve survival, delays from emergency department admission to surgical intervention remain common and are associated with poorer outcomes. Although international guidelines recommend decompression within a four-hour "golden period," data on adherence in Indonesia remain limited. This retrospective cohort study evaluated 91 patients with traumatic brain injury (TBI) who underwent neurosurgical intervention at Saiful Anwar Hospital, Malang, between 2023 and 2024. The association between preoperative time intervals and clinical outcomes, including mortality, Glasgow Outcome Scale at hospital discharge (GOS-HD), and length of stay (LOS), was analyzed. Admission-to-surgery time was not significantly associated with mortality ($p = 0.725$) or GOS-HD ($p = 0.648$). However, prolonged total time to surgery ($p = 0.029$) and extended CT-to-surgery intervals ($p = 0.026$) were significantly associated with increased LOS. These findings indicate that while surgical delays may not directly affect short-term survival or functional outcomes, they contribute to longer hospitalization and reduced care efficiency. Efforts to minimize post-CT delays may improve workflow and optimize trauma care delivery.

Keywords: clinical outcomes; Glasgow Outcome Scale; length of hospital stay; surgical timing; traumatic brain injury

INTRODUCTION

Traumatic brain injury (TBI) remains a critical public health concern worldwide and is a prominent cause of disability and death. Its impact is especially pronounced in low- and middle-income countries, where it represents a significant share of fatalities related to injury. (Demlie et al. 2023). The management of TBI is highly time-critical, requiring prompt and coordinated care from initial resuscitation in the emergency department (ED) to definitive neurosurgical intervention(American College of Surgeons 2024; Egas Terán and González-Andrade 2025). Current guidelines recommend that emergency procedures, such as craniotomy for epidural or subdural hematomas, be performed within a "golden period" of less than four hours from hospital arrival(Menteri Kesehatan Republik Indonesia 2022; Merakis et al. 2024). Delays

in relieving intracranial pressure may exacerbate secondary brain injury and worsen clinical outcomes(Papa and Goldberg 2018; American College of Surgeons 2024). Therefore, reducing delays in the transition from the ED to the operating room is a critical priority in emergency care(Mehmood et al. 2021; Chockalingam et al. 2023).

Emerging evidence further underscores the clinical impact of timely intervention. The implementation of streamlined trauma protocols has been shown to significantly reduce preoperative waiting times and improve survival outcomes, while even incremental delays from ED admission to surgical incision are associated with worse Glasgow Outcome Scale (GOS) scores ((Chockalingam et al. 2023; Rahman et al. 2025; Xue et al. 2026). However, despite the existence of such protocols and guidelines, delays in surgical management remain common in real-world practice(Chockalingam et al. 2023; Rahman et al. 2025). This discrepancy highlights a critical gap between recommended standards and actual clinical performance.

The persistence of these delays reflects the complexity of the TBI care pathway, which involves multiple interdependent processes, including referral systems, access to timely diagnostic imaging, availability of neurosurgical services, and coordination across departments(National Academies of Sciences 2022; Shakir et al. 2023). In LMIC settings, these challenges are further compounded by resource constraints, leading to substantial intrahospital delays, with reported average times to surgery exceeding 150 minutes(Maas et al. 2022; Shakir et al. 2024). These delays represent a modifiable yet inadequately addressed determinant of poor outcomes, indicating that existing guidelines alone are insufficient without context-specific evaluation and system-level optimization.

In Indonesia, evidence regarding the timeliness of TBI management and its impact on patient outcomes remains limited. There is a lack of published data evaluating the interval from hospital admission to surgical intervention and its association with clinical outcomes. Preliminary data from Saiful Anwar Hospital, Malang, suggest that the average time from admission to surgery exceeds recommended targets, with considerable variability. This discrepancy underscores the need for context-specific evaluation of treatment delays and their clinical implications.

This study addresses this gap by evaluating pre-operative timelines in a tertiary referral hospital in Indonesia. The analysis stratifies the pre-operative period into clinically meaningful segments, including the interval from admission to CT imaging and from CT to surgical intervention, and evaluates their interaction with patient-related factors such as age and GCS. This approach provides local evidence and identifies potentially modifiable delays in the care pathway.

This study sought to assess the relationship between the interval from hospital admission to surgical intervention and clinical outcomes in patients with TBI. In particular, it evaluated how preoperative delays influence mortality, GOS-HD, and length of hospital stay.

METHODS

This retrospective cohort study with an analytic observational approach was conducted at Dr. Saiful Anwar General Hospital (RSSA), Malang, Indonesia, using secondary data derived from medical records. Ethical approval was obtained from the Institutional Review Board of Dr. Saiful Anwar General Hospital (Approval No: 400/161/K.3/102.7/2025). All data were fully anonymized prior to analysis by removing personal identifiers, including patient names and medical record numbers, and replacing them with unique study codes. Data were stored in a secure, password-protected database accessible only to the research team.

The study included all patients with traumatic brain injury (TBI) presenting to the emergency department, either directly or via referral, who underwent head CT imaging followed by emergency neurosurgical intervention between January 2023 and December 2024. A total sampling approach was used. Patients with incomplete or missing key temporal data were excluded.

Data were retrospectively extracted using a standardized form. Primary time variables included admission-to-CT, CT-to-operating room (OR), and admission-to-OR intervals. Demographic variables (age, sex) and clinical parameters, including Glasgow Coma Scale (GCS), Revised Trauma Score (RTS), and polytrauma status, were also recorded. The primary outcomes were in-hospital mortality, length of hospital stay (LOS), and Glasgow Outcome Scale at hospital discharge (GOS-HD).

Time intervals were categorized based on clinical relevance and existing guidelines: admission-to-OR (≤4 vs. >4 hours) and admission-to-CT (≤1 vs. >1 hour) ((Menteri Kesehatan Republik Indonesia 2022; NICE 2024). The CT-to-OR interval was analyzed as a continuous variable.

GOS was dichotomized into unfavorable (scores 1–3) and favorable outcomes (scores 4–5). GCS was categorized as severe (≤8) and non-severe (>8). Polytrauma was classified as present or absent, and age was grouped into 0–40 and ≥41 years.

Data were analyzed using SPSS version 25 (IBM Corp., Armonk, NY, USA). Statistical significance was set at $p < 0.05$. Descriptive statistics were reported as frequencies and percentages for categorical variables and mean ± standard deviation for continuous variables. Normality was assessed using the Kolmogorov–Smirnov test.

Given the non-normal distribution of time variables, nonparametric tests were applied. The Mann–Whitney U test was used to assess associations between time intervals and categorical outcomes (mortality and GOS-HD), while Spearman's rank correlation was used for LOS. Chi-square tests were used to evaluate associations between clinical variables and outcomes. Subgroup analyses were performed using predefined time cutoffs to assess interactions between injury severity and treatment delays.

RESULTS AND DISCUSSION

A total of 91 patients with traumatic brain injury (TBI) who underwent emergency neurosurgical intervention between 2023 and 2024 were included in the analysis. The cohort was predominantly male (85.7%), with a mean age of 38.65 ± 20.87 years. The most frequent mechanism of injury was road traffic accidents (63.7%), and the majority of cases were classified as mixed TBI (83.5%) (Table 1). Polytrauma was present in 61.5% of patients, reflecting the high complexity of cases managed at this tertiary referral center (Table 1). GCS score at admission was 8.97 ± 3.79, indicating that a large proportion of patients presented with severe neurological impairment (Table 1).

Table 1. Baseline Demographic and Clinical Characteristics of Patients

Variable	Category	Frequency (n)	Percentage (%) / Mean ± SD
Sex	Male	78	85.7
	Female	13	14.3
Mechanism of Injury	Motor vehicle accident	58	63.7
	Fall	7	7.7
	Assault	2	2.2
	Others	7	7.7
	Unknown	17	18.7
Type of Traumatic Brain Injury	Mixed TBI	76	83.5
	Epidural hematoma (EDH)	9	9.9
	Subarachnoid hemorrhage (SAH)	1	1.1
	Intracerebral hemorrhage (ICH)	5	5.5
Polytrauma	Yes	56	61.5
	No	35	38.5
Age (years)	–	–	38.65 ± 20.87
GCS at Admission	–	–	8.97 ± 3.79
RTS	–	–	6.33 ± 1.24

Overall in-hospital mortality was 44%, while poor functional outcomes at discharge, as measured by the Glasgow Outcome Scale (GOS-HD), were observed in 84.6% of patients (Table 2). The average length of hospital stay (LOS) was 252.16 hours (Table 2). These findings are consistent with global epidemiological patterns identifying young males involved in road traffic accidents as the population at highest risk for severe TBI, underscoring the substantial burden of morbidity and mortality in tertiary care settings; similarly, a study in Malang demonstrated that higher levels of knowledge and positive attitudes toward personal protective equipment (PPE) are associated with

improved compliance, which is critical for reducing the risk of injury.(MAGALHÃES et al. 2022; Vika et al. 2024; Niazie et al. 2026)

Table 2. Distribution of Clinical Outcomes in Patients with Traumatic Brain Injury

Variable	Category	Number of Patients (n)	Percentage (%) / Mean ± SD
Mortality	Deceased	40	44.0
	Survived	51	56.0
GOS at Hospital Discharge (GOS-HD)	Poor outcome	77	84.6
	Good outcome	14	15.4
Length of Hospital Stay (hours)	–	–	252.16 ± 210.36

Analysis of preoperative time intervals demonstrated no statistically significant association between admission-to-operating room (OR) time, admission-to–computed tomography (CT) time, or CT-to-OR interval with mortality or functional outcomes (Figure 1). Conversely, increased time from admission to the operating room ($p = 0.029$, $r = 0.229$) and a longer interval between CT imaging and surgery ($p = 0.026$, $r = 0.234$) were both significantly linked to extended hospital stays (Figure 1).

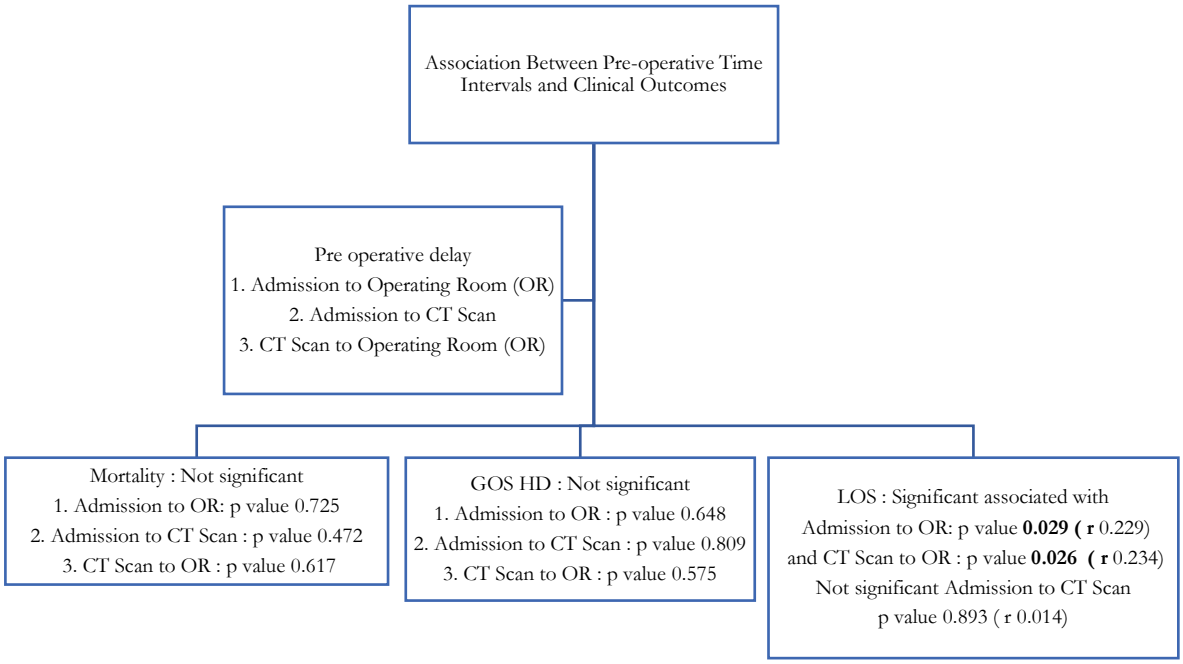

Figure 1. Association Between Pre-operative Time Intervals and Clinical Outcomes

*Length of hospital stay was analyzed using Spearman's rank correlation.

These findings suggest that, while surgical delay may not directly influence mortality or functional recovery, it has a measurable impact on healthcare utilization. This apparent discrepancy with established

trauma principles has been reported in previous studies and is often attributed to triage bias, wherein patients with more severe initial presentations are prioritized for earlier surgical intervention but inherently have poorer prognoses(Egas Terán and González-Andrade 2025). Conversely, patients requiring prolonged stabilization prior to surgery may survive longer but experience extended hospitalization(Tsai et al. 2024; Quispe-Alcocer et al. 2025).

From a clinical standpoint, the observed link between delayed surgical intervention and longer hospital stays highlights the need to improve workflow efficiency, particularly by minimizing the time between CT imaging and definitive surgical management (Feng et al. 2025). Shortening this interval may decrease hospital stay duration and reduce the risk of nosocomial complications, including hospital-acquired infections, while also alleviating healthcare system burden(Khawprapa and Khawprapa 2025). Effective strategies to reduce hospital length of stay require a multifaceted and individualized approach, integrating standardized care pathways such as enhanced recovery after surgery, optimized discharge planning, and coordinated multidisciplinary care, while remaining adaptable to patient-specific factors and evolving clinical evidence to ensure both efficiency and quality outcomes(Hirani et al. 2025).

Further stratified analysis revealed important interactions between clinical severity, treatment delays, and outcomes. Increasing age remained a consistent predictor of mortality regardless of treatment timing (Table 3). The consistent association between advanced age and mortality, irrespective of surgical timing, likely reflects reduced physiological reserve and diminished neuroplasticity in older patients(Niemeyer et al. 2022; Tsai et al. 2024). This observation is consistent with prior studies demonstrating significantly higher risks of mortality among elderly TBI populations, underscoring the need for tailored and aggressive management strategies in this vulnerable group(Chandra and Tobing 2021; Tsai et al. 2024).

Age was associated with GOS-HD independently of CT scan timing; however, no significant association was observed in patients undergoing surgery within 4 hours. These findings may be influenced by the relatively small sample size, which could limit statistical power. Differences compared with previous studies may also be related to variations in how surgical delay is defined. Earlier research has suggested that longer delays to craniotomy are associated with a higher risk of severe disability or death, while shorter delays have not consistently shown a significant impact on GOSE outcomes (Sudadi et al. 2025). In contrast, this study applied a stricter 4-hour threshold, which may account for the observed differences.

A low GCS score (≤ 8) was significantly associated with higher mortality and poorer GOS-HD only in patients experiencing delays beyond four hours to surgery or more than one hour to CT imaging (Figure 2). Likewise, polytrauma showed a significant association with poorer functional outcomes, but only among patients who experienced delayed surgical intervention (Figure 2).

These findings suggest that early surgical management may mitigate the adverse effects of severe neurological injury by limiting secondary brain injury processes, such as increased intracranial pressure and cerebral hypoperfusion(Tsai et al. 2024; Zarmer et al. 2025). However, when delays exceed critical thresholds, baseline injury severity becomes the dominant determinant of outcome.

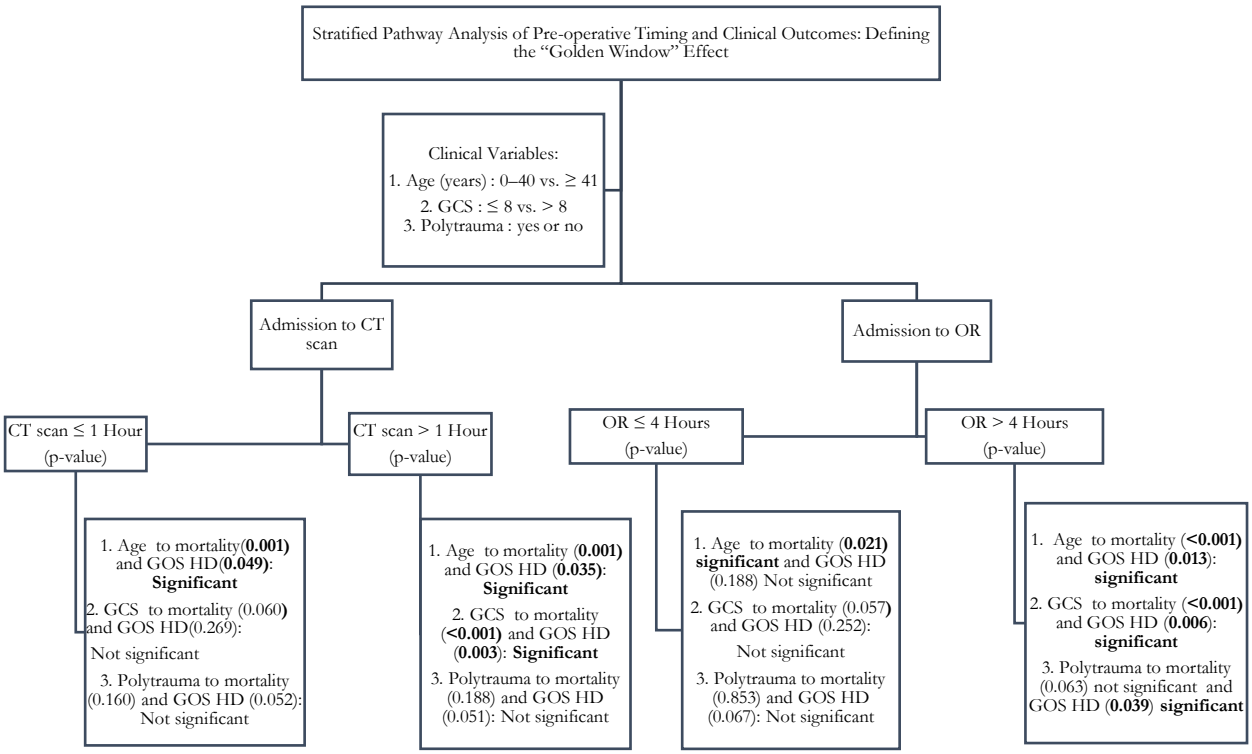

Figure 2. Stratified Pathway Analysis of Pre-operative Timing and Clinical Outcomes: Defining the "Golden Window" Effect.

This study has some limitations. The small number of patients may affect the strength of the analysis. The two-year study period may not represent all variations in clinical practice. As the study was conducted in a single center, the results may not be generalizable to other settings.

CONCLUSION

No significant relationship was found between preoperative delay and either mortality or functional outcome (GOS-HD) in patients with traumatic brain injury. However, a shorter time from CT evaluation to operative management was associated with a reduced duration of hospitalization. Early surgical intervention may attenuate the impact of severe baseline conditions, including low Glasgow Coma Scale scores and polytrauma, whereas delayed intervention allows these factors—along with advanced age—to more strongly determine poor outcomes. These findings highlight the importance of optimizing multidisciplinary trauma workflows, particularly by minimizing the CT-to-operating room interval, and emphasize the need for targeted management strategies in high-risk groups such as elderly patients. Further studies with larger samples and multiple centers are needed to support these findings.

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