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The Association Between Time from Hospital Admission to Surgery and Perioperative Outcomes in Acetabular Fractures: A Retrospective Cohort Study of 133 Patients

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Abstract

Background

The timing of definitive fixation in acetabular fractures is clinically important; however, evidence regarding the association between early surgery, perioperative blood loss, and other early outcomes remains heterogeneous. The primary aim of this study was to evaluate the association between the time from hospital admission to definitive acetabular surgery and perioperative hemoglobin (Hb) decline.

Methods

This single-center retrospective cohort study included 133 patients who underwent surgical treatment between 2015 and 2026. Surgical timing was categorized as ≤ 24 hours, 24–72 hours, and > 72 hours after hospital admission. The primary outcome was the difference between the last preoperative Hb level and the Hb level measured 6 hours postoperatively. Secondary outcomes included red blood cell transfusion within the first 24 postoperative hours, length of intensive care unit (ICU) stay, surgical site infection requiring surgical debridement within 90 days, and in-hospital mortality. The primary model was adjusted for age, sex, Charlson Comorbidity Index, anticoagulant use, polytrauma, fracture complexity, and surgical approach, with HC3 robust standard errors used.

Results

Of the 133 patients, 32 (24.1%) underwent surgery within ≤ 24 hours, 62 (46.6%) within 24–72 hours, and 39 (29.3%) after > 72 hours. The corresponding Hb declines were 2.33 ± 0.68, 1.51 ± 0.72, and 2.00 ± 0.67 g/dL, respectively ($p < 0.001$). In the adjusted model, using the 24–72-hour group as the reference, surgery within ≤ 24 hours was associated with a 0.80 g/dL greater Hb decline (95% CI, 0.62–0.98), whereas surgery after > 72 hours was associated with a 0.42 g/dL greater decline (95% CI, 0.25–0.58); both associations were statistically significant ($p < 0.001$; adjusted $R^2 = 0.736$). Adjusted ICU length of stay was also longer by 6.96 hours in the ≤ 24-hour group and 11.51 hours in the > 72-hour group compared with the 24–72-hour group. Surgical timing was not associated with the likelihood of postoperative transfusion. The interactions between surgical timing and fracture complexity ($p = 0.312$) and between surgical timing and surgical approach ($p = 0.283$) were not statistically significant. Surgical site infection requiring surgical debridement occurred in 11 patients, and 5 patients died during hospitalization.

Conclusions

Among selected patients undergoing surgery for acetabular fractures, definitive surgery performed 24–72 hours after hospital admission was associated with a smaller perioperative Hb decline and a shorter

adjusted ICU stay; however, these associations were not reflected in postoperative red blood cell transfusion rates. These findings should be interpreted as associations rather than evidence of a causal “optimal window” and warrant validation in further studies using time-to-surgery as a continuous variable.

Background

Acetabular fractures are among the most complex injuries in orthopedic trauma because of the need for anatomical reduction, the heterogeneity of fracture morphology, associated injuries, and the extensive surgical exposure often required. The timing of definitive fixation is a clinical decision that directly involves balancing physiological stabilization, surgical feasibility, blood loss, transfusion requirements, intensive care utilization, and early complications [1–4].

The thresholds used to define “early” and “late” acetabular surgery vary across the literature, ranging from 24 hours to several days. Although fixation within the first 24 hours has been reported not to increase blood loss in posterior wall fractures [5], studies involving more heterogeneous acetabular fracture cohorts have similarly demonstrated that surgery performed within the first 48 hours is not associated with increased blood loss or intraoperative transfusion requirements [6]. In contrast, recent studies, particularly those involving an anterior surgical approach, have suggested that earlier surgery may be associated with greater calculated blood loss, although this difference does not consistently translate into increased red blood cell transfusion requirements [7, 8]. These conflicting findings highlight the need to account for differences in fracture patterns, surgical approaches, injury severity, and definitions of surgical timing.

The primary aim of this study was to evaluate the association between the time from hospital admission to definitive acetabular surgery and perioperative hemoglobin (Hb) decline. The secondary aims were to investigate the associations between surgical timing and postoperative red blood cell transfusion, intensive care unit (ICU) length of stay, surgical site infection requiring surgical debridement, and in-hospital mortality, and to determine whether the relationship between surgical timing and Hb decline varied according to fracture complexity or surgical approach. The prespecified hypothesis was that patients undergoing surgery within 24–72 hours would experience a smaller perioperative Hb decline than those undergoing surgery within ≤ 24 hours or after > 72 hours.

Methods

Study Design and Patient Selection

In this single-center retrospective cohort study, patients aged 18–80 years who underwent definitive surgical treatment for acetabular fractures at Mersin City Training and Research Hospital between 2015 and 2026 were evaluated. The study was structured in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines [9]. No missing data were

present for the study variables in the analytical dataset, and 133 patients were included in the final analysis.

Ethics approval:

The study was approved by the Non-Interventional Clinical Research Ethics Committee of Mersin City Training and Research Hospital on August 26, 2026 (approval no. 2026/383).

The inclusion criteria were age between 18 and 80 years and definitive surgical fixation for an acetabular fracture. Patients with periprosthetic acetabular fractures, pathological fractures, those outside the specified age range, and those with major cranial, thoracic, or abdominal trauma requiring emergency surgical intervention were excluded. Patients who received preoperative or intraoperative red blood cell transfusions were excluded to prevent the primary hemoglobin (Hb) outcome from being directly influenced by the transfused red cell mass. The presence of polytrauma was assessed using the binary variable recorded in the clinical records; Injury Severity Score (ISS) and New Injury Severity Score (NISS) data were not available in the analytical dataset.

Definition of Surgical Timing

Surgical timing was categorized according to the interval between hospital admission and the start of definitive acetabular surgery as ≤ 24 hours, 24–72 hours, or > 72 hours. Because the exact time of injury could not be reliably determined for all patients, this study evaluated admission-to-surgery timing rather than injury-to-surgery timing. As time was available only as a categorical variable in the dataset, continuous-time analyses and restricted cubic spline modeling were not performed.

The selection of the 24–72-hour category reflected both the early-versus-late thresholds used in the literature and an exploratory hypothesis concerning biological changes in fracture hematoma during the initial post-injury period [3, 10, 11]. However, the organization of the fracture hematoma was not assumed to constitute a causal mechanism underlying perioperative Hb changes; this biological explanation was considered solely within a hypothesis-generating framework.

Variables and Outcome Measures

Preoperative Hb was defined as the last Hb measurement obtained before surgery, whereas postoperative Hb was defined as the value measured 6 hours after surgery. Perioperative Hb decline was calculated as the last preoperative Hb level minus the postoperative 6-hour Hb level. This variable was considered an indicator of perioperative hematological change associated with the surgical episode rather than a direct measure of intraoperative blood loss.

The primary outcome was perioperative Hb decline. Secondary outcomes included transfusion of ≥ 1 unit of red blood cells within the first 24 postoperative hours, the total number of red blood cell units

administered during the first 24 postoperative hours, intensive care unit (ICU) length of stay (hours), surgical debridement for surgical site infection within 90 days postoperatively, and in-hospital mortality during the index admission.

Demographic and clinical variables included age, sex, Charlson Comorbidity Index, American Society of Anesthesiologists (ASA) physical status classification, anticoagulant use, and the presence of polytrauma. Fractures were recorded according to the Judet–Letournel classification [1]. For the analysis, fracture complexity was dichotomized into simple and complex categories. Surgical approaches were classified as posterior, anterior, or combined anterior and posterior. Analyses of individual Judet–Letournel fracture subtypes were planned as exploratory and descriptive only because of the small numbers in some subgroups.

Statistical Analysis

Continuous variables were reported as means ± standard deviations, and categorical variables as numbers and percentages. Continuous variables were compared across the three surgical timing groups using one-way analysis of variance (ANOVA). When the overall test was statistically significant, pairwise comparisons were performed using Tukey's honestly significant difference (HSD) procedure. Categorical variables were compared using the Pearson chi-square test or Fisher's exact test when expected cell counts were low.

A multivariable linear regression model was fitted for the primary Hb outcome, using HC3 robust standard errors to account for heteroscedasticity. The prespecified covariates were age, sex, Charlson Comorbidity Index, anticoagulant use, polytrauma, fracture complexity, and surgical approach. ASA physical status was not included in the primary model to reduce the potential for unnecessary collinearity between ASA classification and comorbidity burden. An alternative model substituting ASA physical status for the Charlson Comorbidity Index was performed as a sensitivity analysis. ICU length of stay was analyzed using linear regression with the same covariate structure and HC3 robust standard errors; a sensitivity analysis using log-transformed ICU length of stay was also performed. Binary logistic regression with the same covariates was used to analyze the occurrence of any postoperative red blood cell transfusion.

To assess whether the association between surgical timing and Hb decline varied according to fracture complexity or surgical approach, surgical timing × fracture complexity and surgical timing × surgical approach interaction terms were tested in separate models, and joint Wald tests were reported. Model diagnostics included the variance inflation factor (VIF), the Breusch–Pagan test for heteroscedasticity, residual distribution assessment, Cook's distance, and leave-one-out sensitivity analysis. Because the numbers of surgical site infections requiring surgical debridement and in-hospital deaths were low (n = 11 and n = 5, respectively), multivariable regression analyses were not performed for these outcomes. A two-sided p-value < 0.05 was considered statistically significant.

Results

Patient Characteristics

Of the 133 patients, 32 (24.1%) underwent surgery within ≤ 24 hours, 62 (46.6%) within 24–72 hours, and 39 (29.3%) after > 72 hours. The mean age was 50.5 ± 10.9 years, and 69.9% of the patients were male. Eighty patients (60.2%) had simple fractures, whereas 53 (39.8%) had complex fractures. The surgical approach was posterior in 60 patients (45.1%), anterior in 43 (32.3%), and combined anterior and posterior in 30 (22.6%). No significant differences in baseline demographic or clinical characteristics were observed among the surgical timing groups (Table 1).

Table 1
Baseline characteristics according to surgical timing group

Variable	≤ 24 h (n = 32)	24–72 h (n = 62)	> 72 h (n = 39)	p-value
Age, years	51.16 ± 11.35	49.76 ± 11.21	51.05 ± 10.22	0.781
Charlson Comorbidity Index	2.06 ± 1.52	1.94 ± 1.41	2.08 ± 1.16	0.851
Preoperative Hb, g/dL	13.13 ± 1.16	13.56 ± 1.00	13.22 ± 1.03	0.105
Male sex, n (%)	19 (59.4)	44 (71.0)	30 (76.9)	0.268
Complex fracture, n (%)	12 (37.5)	23 (37.1)	18 (46.2)	0.632
ASA I / II / III / IV, n	3 / 9 / 15 / 5	6 / 23 / 25 / 8	4 / 7 / 24 / 4	0.460
Posterior/anterior/combined approach n	14 / 11 / 7	28 / 22 / 12	18 / 10 / 11	0.803
Anticoagulant use, n (%)	8 (25.0)	14 (22.6)	10 (25.6)	0.931
Polytrauma, n (%)	2 (6.3)	6 (9.7)	2 (5.1)	0.709

Primary Outcome: Perioperative Hemoglobin Decline

Hb decline differed significantly among the surgical timing groups: 2.33 ± 0.68 g/dL in the ≤ 24-hour group, 1.51 ± 0.72 g/dL in the 24–72-hour group, and 2.00 ± 0.67 g/dL in the > 72-hour group (overall $p < 0.001$). Tukey post hoc analysis showed that Hb decline in the 24–72-hour group was, on average, 0.82 g/dL lower than that in the ≤ 24-hour group (adjusted $p < 0.001$) and 0.49 g/dL lower than that in the > 72-hour group (adjusted $p = 0.002$). The difference between the ≤ 24-hour and > 72-hour groups was not statistically significant ($p = 0.120$).

In the primary model adjusted for the prespecified covariates, using the 24–72-hour group as the reference, surgery within ≤ 24 hours was associated with a 0.80 g/dL greater Hb decline (95% CI, 0.62–

0.98; p < 0.001), whereas surgery after > 72 hours was associated with a 0.42 g/dL greater Hb decline (95% CI, 0.25–0.58; p < 0.001). The model had an R^2 of 0.756 and an adjusted R^2 of 0.736. Complex fractures were independently associated with a 0.22 g/dL greater Hb decline (95% CI, 0.01–0.43; p = 0.044). The surgical approach also had a substantial association with Hb decline: compared with the anterior approach, the posterior approach was associated with a smaller decline, whereas the combined approach was associated with a greater decline.

Table 2
Early perioperative outcomes according to surgical timing

Outcome	≤ 24 h	24–72 h	> 72 h	p-value
Hb decline, g/dL	2.33 ± 0.68	1.51 ± 0.72	2.00 ± 0.67	< 0.001
ICU length of stay, hours	65.09 ± 19.02	57.05 ± 18.76	72.05 ± 21.01	0.001
Red blood cell units, first 24 h	0.78 ± 0.91	0.63 ± 0.75	0.69 ± 0.73	0.672
Any red blood cell transfusion, n (%)	15 (46.9)	29 (46.8)	21 (53.8)	0.768
Surgical site infection requiring surgical debridement, n (%)	4 (12.5)	5 (8.1)	2 (5.1)	0.568
In-hospital mortality, n (%)	2 (6.3)	2 (3.2)	1 (2.6)	0.709

Secondary Outcomes

Transfusion of ≥ 1 unit of red blood cells within the first 24 postoperative hours was administered to 65 of 133 patients (48.9%). The corresponding proportions in the ≤ 24-hour, 24–72-hour, and > 72-hour groups were 46.9%, 46.8%, and 53.8%, respectively (Fisher's exact test, p = 0.768). In the adjusted logistic regression model, neither surgery within ≤ 24 hours (OR, 1.00; 95% CI, 0.36–2.79; p = 0.998) nor surgery after > 72 hours (OR, 1.19; 95% CI, 0.46–3.05; p = 0.723) was associated with a statistically significant change in the odds of transfusion compared with the 24–72-hour group.

ICU length of stay differed significantly among the groups (overall p = 0.001). In the unadjusted Tukey analysis, ICU length of stay was longer in the > 72-hour group than in the 24–72-hour group (mean difference, 15.0 hours; adjusted p < 0.001); the pairwise difference between the ≤ 24-hour and 24–72-hour groups was not statistically significant in the unadjusted analysis (p = 0.144). However, after adjustment for clinical and anatomical covariates, using the 24–72-hour group as the reference, ICU length of stay was longer by 6.96 hours in the ≤ 24-hour group (95% CI, 3.23–10.68; p < 0.001) and by 11.51 hours in the > 72-hour group (95% CI, 8.03–14.99; p < 0.001). The adjusted R^2 of the ICU model was 0.835. The direction and statistical significance of the associations were maintained in the sensitivity analysis using log-transformed ICU length of stay.

Table 3
Associations between surgical timing and adjusted outcomes (reference: 24–72 hours)

Outcome	Surgical timing	Effect estimate	95% CI	p-value
Hb decline	≤ 24 h	β = 0.80	0.62–0.98	< 0.001
Hb decline	> 72 h	β = 0.42	0.25–0.58	< 0.001
ICU length of stay	≤ 24 h	β = 6.96 h	3.23–10.68	< 0.001
ICU length of stay	> 72 h	β = 11.51 h	8.03–14.99	< 0.001
Any transfusion	≤ 24 h	OR = 1.00	0.36–2.79	0.998
Any transfusion	> 72 h	OR = 1.19	0.46–3.05	0.723

Note: The primary models were adjusted for age, sex, Charlson Comorbidity Index, anticoagulant use, polytrauma, fracture complexity, and surgical approach. HC3 robust standard errors were used for the Hb and ICU models.

Fracture Complexity and Surgical Approach

Hb decline was greater in patients with complex fractures than in those with simple fractures (2.27 ± 0.80 vs. 1.58 ± 0.61 g/dL; $p < 0.001$), and ICU length of stay was longer (79.91 ± 19.73 vs. 52.44 ± 11.63 hours; $p < 0.001$). Postoperative transfusion was administered to 38 of 53 patients with complex fractures (71.7%) and 27 of 80 patients with simple fractures (33.8%).

Hb decline according to surgical approach was 1.37 ± 0.50 g/dL for the posterior approach, 1.84 ± 0.58 g/dL for the anterior approach, and 2.85 ± 0.44 g/dL for the combined anterior and posterior approach ($p < 0.001$). ICU length of stay was 51.87 ± 11.56, 57.33 ± 10.21, and 95.10 ± 10.17 hours, respectively ($p < 0.001$). The corresponding transfusion rates were 40.0% for the posterior approach, 34.9% for the anterior approach, and 86.7% for the combined approach.

Table 4
Outcomes according to fracture complexity and surgical approach

Group	n	Hb decline, g/dL	ICU stay, hours	Transfusion, n (%)	SSI requiring debridement, n (%) (%)	Mortality, n (%)
Simple fracture	80	1.58 ± 0.61	52.44 ± 11.63	27 (33.8)	4 (5.0)	2 (2.5)
Complex fracture	53	2.27 ± 0.80	79.91 ± 19.73	38 (71.7)	7 (13.2)	3 (5.7)
Posterior approach	60	1.37 ± 0.50	51.87 ± 11.56	24 (40.0)	3 (5.0)	2 (3.3)
Anterior approach	43	1.84 ± 0.58	57.33 ± 10.21	15 (34.9)	3 (7.0)	1 (2.3)
Combined anterior and posterior approach	30	2.85 ± 0.44	95.10 ± 10.17	26 (86.7)	5 (16.7)	2 (6.7)

Stratified Analyses and Interaction Testing

A smaller Hb decline was observed in the 24–72-hour group across both simple and complex fractures and across all three surgical approach categories (Table 5). However, interaction analyses did not demonstrate a statistically significant variation in the association between surgical timing and Hb decline according to fracture complexity (joint Wald test, p = 0.312). Similarly, the interaction between surgical timing and surgical approach was not statistically significant (joint Wald test, p = 0.283). Therefore, the consistency in the direction of the associations across subgroups was not interpreted as evidence of formal effect modification.

Table 5
Stratified analysis of the association between surgical timing and Hb decline according to fracture complexity and surgical approach

Subgroup	n	≤ 24 h	24–72 h	> 72 h	p-value
Simple fracture	80	2.11 ± 0.57 (n = 20)	1.25 ± 0.53 (n = 39)	1.68 ± 0.37 (n = 21)	< 0.001
Complex fracture	53	2.70 ± 0.70 (n = 12)	1.96 ± 0.80 (n = 23)	2.38 ± 0.74 (n = 18)	0.023
Posterior approach	60	1.81 ± 0.36 (n = 14)	1.03 ± 0.41 (n = 28)	1.55 ± 0.35 (n = 18)	< 0.001
Anterior approach	43	2.43 ± 0.48 (n = 11)	1.51 ± 0.47 (n = 22)	1.90 ± 0.32 (n = 10)	< 0.001
Combined anterior and posterior approach	30	3.22 ± 0.34 (n = 7)	2.63 ± 0.33 (n = 12)	2.84 ± 0.46 (n = 11)	0.014

Infection and Mortality

Surgical site infection requiring surgical debridement within 90 days postoperatively occurred in 11 patients (8.3%). The events occurred in 4 of 32 patients (12.5%) in the ≤ 24-hour group, 5 of 62 patients (8.1%) in the 24–72-hour group, and 2 of 39 patients (5.1%) in the > 72-hour group (Fisher's exact test, p = 0.568). In-hospital mortality occurred in 5 of 133 patients (3.8%), with no statistically significant difference among the surgical timing groups (Fisher's exact test, p = 0.709). Multivariable analyses were not performed for these two outcomes because of the low number of events.

Model Diagnostics and Sensitivity Analyses

In the primary Hb model, variance inflation factor (VIF) values ranged from 1.09 to 6.30, and no variable had a VIF > 10. The Breusch–Pagan test provided no evidence of heteroscedasticity (p = 0.718), and the residual distribution showed no substantial deviation from normality (Jarque–Bera test, p = 0.819). The maximum Cook's distance was 0.051. In the leave-one-out analysis, the surgical timing coefficient ranged from 0.77 to 0.82 g/dL for the ≤ 24-hour group and from 0.40 to 0.44 g/dL for the > 72-hour group. In the alternative model substituting ASA physical status for the Charlson Comorbidity Index, the timing coefficients remained unchanged (≤ 24 hours: β = 0.80; >72 hours: β = 0.42; both p < 0.001). These findings support the robustness of the primary association between surgical timing and Hb decline to model specification and individual observations.

Discussion

The principal finding of this retrospective cohort study was that definitive acetabular surgery performed 24–72 hours after hospital admission was associated with a smaller perioperative hemoglobin (Hb) decline than surgery performed within ≤ 24 hours or after > 72 hours. This association persisted after adjustment for demographic characteristics, comorbidity burden, anticoagulant use, polytrauma, fracture complexity, and surgical approach, and remained consistent across alternative model specifications and leave-one-out sensitivity analyses. However, the likelihood of postoperative red blood cell transfusion was not associated with surgical timing. This distinction indicates that the observed change in Hb should not be considered directly equivalent to a clinically meaningful requirement for transfusion.

The literature on the timing of acetabular surgery remains inconclusive. Furey et al. reported that surgery within the first 24 hours did not increase estimated blood loss in patients with posterior wall fractures [5]. Parry et al. compared surgery performed within ≤ 48 hours with later surgery and found that early fixation did not increase blood loss or intraoperative transfusion requirements [6]. Similarly, Hidden et al. reported that, among medically optimized patients undergoing an anterior approach, surgery within the first 24 hours did not increase bleeding, transfusion requirements, or mortality, while potentially reducing hospital length of stay [12].

However, two studies published in 2024 demonstrated that earlier surgery for acetabular fractures treated through an anterior approach may be associated with greater calculated perioperative blood loss

without a significant increase in red blood cell transfusion [7, 8]. This observation is notably consistent with the distinction between Hb decline and transfusion outcomes observed in our study. Our cohort included posterior and combined approaches in addition to the anterior approach; therefore, surgical approach was included in the primary model, and the interaction between surgical timing and surgical approach was assessed separately. The absence of a statistically significant interaction suggests that the observed association between surgical timing and Hb decline was not explained solely by the distribution of a single surgical approach category. Nevertheless, the statistical power of the subgroup analyses was limited.

Fracture complexity and surgical approach were independently associated with outcomes, irrespective of surgical timing. Patients with complex fractures experienced greater Hb declines, longer ICU stays, and higher transfusion requirements. In particular, the combined anterior and posterior approach was associated with the greatest Hb decline and the longest ICU stay. These findings suggest that surgical approach is not merely a technical variable but may also serve as a marker of the underlying anatomical complexity and operative burden of the fracture. Accordingly, jointly evaluating fracture complexity and surgical approach, while assessing potential collinearity, is important for the statistical analysis.

The smaller Hb decline observed in the 24–72-hour group does not establish the existence of a biological “optimal window” related to fracture hematoma organization. Fracture hematoma forms immediately after injury and undergoes dynamic changes during the first few days, including inflammatory cell infiltration, fibrin matrix formation, and early reparative processes [11]. However, the time axis in our study began at hospital admission rather than at the time of injury. Therefore, local fracture hematoma biology may provide a hypothesis for further investigation, but it does not constitute a confirmed mechanism explaining the observed clinical association. In particular, the greater Hb decline observed in the > 72-hour group cannot be attributed to a specific mechanism, such as early fibrosis, on the basis of the available data.

The shorter ICU length of stay observed in the 24–72-hour group is clinically noteworthy. However, this outcome may be influenced not only by surgical timing but also by fracture complexity, surgical approach, physiological optimization, and institutional discharge practices. Although the persistence of the association in adjusted and log-transformed models strengthens the statistical robustness of the findings, it does not establish causality. Similarly, the findings regarding infection and mortality should be interpreted as exploratory safety data because of the low number of events.

Clinically, these findings suggest that, among selected patients who have achieved hemodynamic stabilization and are suitable for definitive fixation, surgery performed 24–72 hours after hospital admission may be associated with a smaller perioperative Hb decline. However, the results do not support delaying surgery in a stable patient solely to reach this time window, nor do they justify operating on a patient who has not completed resuscitation based on a predefined time threshold. Surgical timing should be determined through an individualized assessment of physiological readiness, fracture pattern, surgical approach, surgical team experience, and institutional resources.

Limitations

The main limitations of this study are its retrospective, single-center design, which precludes the complete exclusion of confounding by indication and unmeasured confounding. The clinical factors underlying the decision to perform surgery earlier or later were not fully captured in the analytical dataset.

Surgical timing was defined as the interval from hospital admission to surgery, as the exact time of injury was not reliably available. Therefore, the timing intervals examined in this study are not directly equivalent to those reported in studies using injury-to-surgery intervals. Furthermore, the availability of surgical timing data only in three categorical groups precluded the assessment of a continuous dose–response relationship, potential U- or J-shaped associations, and a true inflection point.

Perioperative Hb decline is not a direct measure of intraoperative blood loss and may be influenced by the volume of crystalloid and colloid administration, hemodilution, and perioperative fluid balance. Patient-level data on intraoperative fluid volumes, estimated or calculated blood loss, and operative duration were not available in the analytical dataset. Although excluding patients who required preoperative or intraoperative red blood cell transfusion improved the interpretability of the primary outcome, this exclusion may have introduced selection bias by omitting patients with more severe hemorrhagic presentations.

In the absence of Injury Severity Score (ISS) or New Injury Severity Score (NISS) data, overall trauma burden could be represented only by a binary polytrauma variable. Because surgical approach was associated with fracture complexity, residual structural confounding remains possible. Nevertheless, variance inflation factor assessment, interaction analyses, and sensitivity analyses did not indicate substantial model instability. The small number of surgical site infections requiring surgical debridement (n = 11) and in-hospital deaths (n = 5) substantially limited the statistical power for these outcomes. Finally, Judet–Letournel fracture subtypes were reported for exploratory purposes only because of small cell counts.

Conclusion

In this retrospective cohort of 133 patients, definitive acetabular fracture surgery performed 24–72 hours after hospital admission was associated with a smaller perioperative Hb decline and a shorter ICU length of stay after adjustment for clinical and anatomical covariates. Postoperative red blood cell transfusion requirements did not differ significantly according to surgical timing. No significant effect modification of the association between surgical timing and Hb decline by fracture complexity or surgical approach was identified. These findings support the 24–72-hour interval as a clinically relevant association rather than an established optimal surgical window, warranting further evaluation in prospective studies with continuously measured timing data.

Abbreviations

ANOVA, analysis of variance;

ASA, American Society of Anesthesiologists;

CI, confidence interval;

Hb, hemoglobin;

HC3, heteroscedasticity-consistent covariance estimator 3;

HSD, honestly significant difference;

ICU, intensive care unit;

ISS, Injury Severity Score;

NISS, New Injury Severity Score;

OR, odds ratio;

STROBE, Strengthening the Reporting of Observational Studies in Epidemiology;

VIF, variance inflation factor.

Declarations

Ethics approval and consent to participate

The study was approved by the Non-Interventional Clinical Research Ethics Committee of Mersin City Training and Research Hospital on August 26, 2026 (approval no. 2026/383). The requirement for informed consent was waived by the ethics committee due to the retrospective nature of the study.

Consent for publication

Not applicable

Clinical trial number

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

ANT, ID, EE conceived and designed the study.

ANT, AMK, UA collected the data.

ANT, ID, HTS performed the statistical analysis.

ANT, UA, EE interpreted the results and drafted the manuscript.

All authors critically revised the manuscript, read and approved the final version.

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