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Association Between Time to Definitive Surgical Fixation and Clinical Outcomes in Patients with Unstable Pelvic Fractures

Ali Dheyaa Abed Alkadhim[1]
Kaisser Kareem Jassim Al-Janabi[2]
Montadher Najem Oubaid Fanharawy[3]

Abstract

Background: Unstable pelvic fractures represent life-threatening injuries associated with substantial hemorrhage, multi-organ dysfunction, and high mortality. The optimal timing of definitive surgical fixation remains a subject of considerable debate, particularly in resource-limited settings where logistical and infrastructural constraints frequently delay operative intervention.

Objectives: To evaluate the association between the time interval from injury to definitive surgical fixation and clinical outcomes—including postoperative complications, intraoperative blood loss, length of hospital stay, intensive care unit (ICU) duration, and functional recovery—in patients presenting with unstable pelvic fractures at a Al-Hilla General Teaching Hospital.

Methods: A retrospective cohort study was conducted on 95 patients with Tile Type B and Type C pelvic fractures treated between January 2018 and December 2022. Patients were stratified into two groups: early fixation (≤24 hours from injury) and delayed fixation (>24 hours). Primary outcomes included overall complication rates, intraoperative blood loss, and transfusion requirements. Secondary outcomes encompassed ICU and hospital length of stay, functional outcomes assessed by the Majeed Pelvic Outcome Score at six months, and mortality.

Results: The early fixation group (n = 52) demonstrated significantly lower intraoperative blood loss (680 ± 210 mL vs. 890 ± 275 mL; $p = 0.001$), reduced packed red blood cell transfusion requirements (2.8 ± 1.4 vs. 4.1 ± 1.9 units; $p < 0.001$), and shorter ICU (median 4 vs. 8 days; $p < 0.001$) and hospital stays (median 12 vs. 19 days; $p < 0.001$). The overall complication rate was significantly lower in the early group (34.6% vs. 62.8%; $p = 0.006$). Functional recovery at six months, measured by the Majeed Score, was superior in the early fixation group (74.2 ± 10.6 vs. 61.8 ± 13.4; $p < 0.001$). Multivariate analysis identified delayed fixation as an independent predictor of complications (adjusted OR = 3.21; 95% CI: 1.48–6.97; $p = 0.003$).

Conclusion: Early definitive surgical fixation of unstable pelvic fractures within 24 hours of injury is associated with significantly improved clinical outcomes in terms of blood loss, complication rates, length of stay, and functional recovery. Institutional protocols should prioritize timely stabilization in haemodynamically resuscitated patients.

Keywords: Pelvic fractures; surgical fixation; timing of surgery; unstable pelvis; Tile classification; Baghdad; trauma outcomes; damage control orthopaedics; postoperative complications; Majeed Score

[1, 2,3] Babil health directorate, Al-Hilla General Teaching Hospital

1. INTRODUCTION

Unstable pelvic fractures represent one of the most challenging and potentially fatal injuries encountered in trauma surgery. They are most commonly the result of high-energy mechanisms including road traffic accidents, falls from significant heights, and crush injuries. The pelvis is a richly vascularized anatomical compartment, and its disruption is associated with catastrophic haemorrhage, multi-organ dysfunction, and mortality rates that have been reported to range from 6% to 35% in the peer-reviewed literature [1,2]. In Baghdad, as in many major cities in the developing world, the burden of road traffic accidents continues to impose an enormous strain on healthcare systems. Iraq's orthopaedic trauma infrastructure has evolved considerably over the past decade, yet challenges related to resource availability, delayed referrals, and emergency department overcrowding continue to influence the timing and quality of surgical care for complex pelvic injuries.

The classification of pelvic ring injuries provides the clinical framework upon which treatment decisions are based. The Tile classification, later incorporated into the AO/OTA system, divides injuries into Type A (rotationally and vertically stable), Type B (rotationally unstable, vertically stable), and Type C (rotationally and vertically unstable) fractures [1]. Type B and Type C injuries require operative stabilisation to restore pelvic ring integrity, minimise ongoing haemorrhage, and facilitate early mobilisation. Burgess et al. [3] advanced the understanding of injury mechanisms by demonstrating that the pattern of pelvic disruption is closely related to the vector of applied force, which in turn predicts the severity of haemorrhage and associated visceral injuries. Dalal et al. [4] further delineated the relationship between fracture classification and systemic physiological derangement, showing that vertical shear injuries carry the highest transfusion burden and mortality risk.

The clinical management of unstable pelvic fractures has evolved significantly over the past three decades. Damage control resuscitation, including permissive hypotension, haemostatic resuscitation with balanced ratios of packed red blood cells (pRBCs), fresh frozen plasma (FFP), and platelets, and the avoidance of crystalloid overload, has transformed early haemorrhage management [5][6][7][8][9][10][11]. In parallel, damage control orthopaedics (DCO) emerged as a conceptual framework advocating temporary external fixation, angiographic embolisation, or extraperitoneal pelvic packing as initial haemostatic measures, with definitive surgical fixation deferred until physiological stability has been achieved [6][12][13][14][15][16][17][18]. This approach, championed by Ertel et al. [15] and Cothren et al. [18], reduced early mortality by avoiding the 'second hit' phenomenon associated with prolonged anaesthesia and operative stress in physiologically compromised patients.

Despite the conceptual clarity of DCO, the determination of what constitutes the ideal timing for definitive surgical fixation remains contentious. Earlier studies, particularly those by Vallier et al. [12], demonstrated that early definitive stabilisation of unstable pelvic and acetabular fractures was associated with reductions in pulmonary complications, transfusion requirements, and length of hospital stay. However, many of these studies were conducted in high-income countries with well-resourced trauma systems capable of mobilising multidisciplinary teams, interventional radiology, and blood banking services at short notice. Transferring these findings to a middle-income setting such as Baghdad requires careful contextualisation. Hauschild et al. [13], drawing on data from the German Pelvic Injury Register, identified injury severity score (ISS), presence of haemodynamic instability at admission, and fracture type as key determinants of outcome, while Giannoudis et al. [10] highlighted the importance of associated injuries—particularly thoracoabdominal trauma—as modifiers of the risk-benefit calculus for early versus delayed surgery [19][20][21][22].

The haemodynamic sequelae of pelvic fracture derive from both arterial and venous injury. Venous haemorrhage from the presacral and iliac venous plexuses accounts for approximately 80% of pelvic bleeding, while arterial injury—most frequently of the internal iliac and its branches—contributes the remainder but is associated with disproportionate haemodynamic instability and higher mortality [17,22].

Pelvic ring reduction and stabilisation reduce the pelvic volume, tamponading venous haemorrhage, and this mechanical benefit applies regardless of whether external or internal fixation is employed [19]. The decision between angiographic embolisation and extraperitoneal pelvic packing as adjuncts to mechanical stabilisation continues to evolve; Osborn et al. [16] and Totterman et al. [14] demonstrated comparable haemostatic efficacy for both approaches, and many centres now adopt a protocol-driven sequential or hybrid strategy [23][24][25][26][27][28][29][30].

The biological rationale for early definitive fixation is rooted in the post-injury inflammatory cascade. Fracture haematoma, devitalised tissue, and ongoing haemorrhage collectively amplify the systemic inflammatory response, promoting cytokine release and organ dysfunction [31]. Hildebrand et al. [31] characterised the interplay between the initial injury and subsequent operative insults, demonstrating that prolonged delay can paradoxically increase operative risk as the systemic inflammatory milieu becomes increasingly hostile to physiological recovery. Pape et al. [6,28] proposed the 'borderline patient' concept, acknowledging that a subgroup of polytraumatised patients may not fit neatly into either an 'early total care' or a rigid DCO pathway, and that individualised decision-making informed by serial physiological markers—lactate, base deficit, coagulation parameters—is essential [31][32][33].

From the perspective of functional outcomes, the long-term consequences of delayed pelvic stabilisation include malunion, chronic pelvic pain, limb length discrepancy, sacral neuropathy, and disability. The Majeed Pelvic Outcome Score, a validated disease-specific instrument, captures pain, work capacity, sitting, sexual intercourse, and standing function, and has been widely employed to benchmark recovery following operative pelvic fixation [2]. Pohlemann et al. [2] demonstrated in a landmark study that anatomical reduction and stable fixation were the strongest predictors of favourable functional outcomes at two years, underscoring the importance not only of whether surgery is performed but also of when. Stahel et al. [34] reinforced the utility of systematic decision-making frameworks, including algorithmic approaches to external fixation, to standardise care and reduce outcome variability [35][36].

Epidemiological data from Baghdad and the broader Iraqi context are limited, and the existing literature relies predominantly on registry data from Europe and North America [7,37,38]. This paucity of regional evidence constrains the ability of local clinicians to make evidence-based decisions tailored to the specific logistical and clinical realities of Baghdad's trauma hospitals.

The present study was therefore designed to evaluate, within a real-world Iraqi clinical context, the association between time to definitive surgical fixation and a comprehensive set of clinical outcomes in patients with unstable pelvic fractures. We hypothesised that early surgical fixation, defined as operative stabilisation within 24 hours of injury in haemodynamically resuscitated patients, would be independently associated with reduced complications, lower transfusion burden, shorter hospital and ICU stays, and superior functional recovery compared with delayed fixation. The findings are intended to inform institutional protocols and contribute to the nascent evidence base on pelvic trauma management in Iraq and the Middle East.

2. METHODOLOGY

2.1 Study Design and Setting

This was a single-centre, retrospective cohort study conducted at a Al-Hilla General Teaching Hospital, a 220-bed tertiary-level facility located in Al-Hilla, Iraq. The hospital operates a dedicated trauma unit with orthopaedic surgical capability, including an intraoperative fluoroscopy suite for percutaneous fixation. Data were extracted from the institutional trauma registry and electronic medical records for the period spanning January 2018 to December 2022. Informed consent was waived given the retrospective nature of the study, in accordance with national guidelines for observational research using anonymised patient data.

2.2 Participant Selection

All adult patients (age ≥ 18 years) admitted with a primary diagnosis of unstable pelvic ring fracture

(Tile Type B or Type C) who subsequently underwent definitive surgical fixation during the study period were considered for inclusion. The Tile classification was assigned prospectively by the operating orthopaedic surgeon at the time of admission, based on clinical examination, anteroposterior pelvic radiograph, and computed tomography (CT) of the pelvis with axial, coronal, and sagittal reconstructions. Inclusion criteria required that the patient had survived to definitive fixation, had a minimum follow-up of six months, and had a complete operative and clinical record. Patients were excluded if they sustained isolated acetabular fractures without pelvic ring involvement, if the fracture was pathological, if the patient was transferred from another institution with a prior surgical intervention for the same injury, if definitive records were incomplete, or if the patient was lost to follow-up before the six-month functional assessment. A total of 95 patients met all eligibility criteria and formed the analytic cohort.

2.3 Exposure Definition and Group Stratification

The primary exposure variable was the time interval from confirmed injury to definitive surgical fixation, defined as the time from documented mechanism of injury or emergency department arrival (whichever was earlier) to skin incision for definitive pelvic ring reconstruction. Patients were stratified into two groups based on a 24-hour threshold: the early fixation group (time to surgery ≤24 hours, n = 52) and the delayed fixation group (time to surgery >24 hours, n = 43). This threshold was selected a priori based on prevailing evidence in the orthopaedic trauma literature [6,12,28] and consensus within the institutional trauma protocol. Damage control procedures—including external fixation, angioembolisation, and extraperitoneal packing—performed prior to definitive fixation were recorded but not classified as definitive surgery for the purposes of this study.

2.4 Outcome Variables

The primary outcome was the occurrence of any postoperative complication within 30 days of surgery, defined as a composite of wound infection (superficial or deep, per CDC criteria), deep vein thrombosis (DVT, confirmed by Doppler ultrasonography), pulmonary embolism (PE, confirmed by CT pulmonary angiography), pneumonia (radiographic and clinical criteria), acute respiratory distress syndrome (ARDS, Berlin Definition), and 30-day in-hospital mortality. Secondary outcomes included: (1) intraoperative blood loss, estimated by the anaesthetic team using a gravimetric and volumetric method; (2) intraoperative transfusion requirements, expressed as units of pRBCs and FFP; (3) ICU length of stay in days; (4) total hospital length of stay in days; (5) functional outcome at six months assessed using the validated Majeed Pelvic Outcome Score (range 0–100, higher scores indicating better function); and (6) return to pre-injury occupational status at six months.

2.5 Covariates and Confounders

The following baseline variables were collected to characterise the study population and to serve as potential confounders in multivariable analysis: age; sex; mechanism of injury; Injury Severity Score (ISS); Glasgow Coma Scale (GCS) at emergency department presentation; initial systolic blood pressure (SBP); initial haemoglobin concentration; Tile fracture type (B vs. C); presence of associated injuries (thoracic, abdominal, head, and long-bone fractures); need for damage control procedures prior to definitive fixation; and ASA physical status classification. ISS was calculated by the trauma registry team using the Abbreviated Injury Scale (AIS) 2005 revision.

2.6 Surgical Technique

Definitive surgical fixation was performed by consultant orthopaedic trauma surgeons with specific expertise in pelvic ring reconstruction. The operative approach was determined by the fracture pattern: anterior ring injuries were addressed with symphyseal plating or anterior external fixator conversion to internal fixation (INFIX), posterior ring injuries were treated with percutaneous iliosacral screw fixation under fluoroscopic guidance for Tile B sacroiliac joint injuries, or posterior open reduction and internal fixation with locking plates for displaced sacral fractures and sacroiliac dislocations in Tile C injuries. All

patients received standard perioperative thromboprophylaxis with low-molecular-weight heparin commencing 12 hours postoperatively, antibiotic prophylaxis with a first-generation cephalosporin, and a structured physiotherapy mobilisation protocol.

2.7 Statistical Analysis

Statistical analyses were performed using SPSS version 27.0 (IBM Corporation, Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro-Wilk test and expressed as mean ± standard deviation (SD) for normally distributed data or median with interquartile range (IQR) for non-normally distributed data. Group comparisons of continuous variables were performed using the independent samples t-test or the Mann-Whitney U test as appropriate. Categorical variables were expressed as frequencies and percentages and compared using the chi-square test or Fisher's exact test where cell counts were fewer than five. Multivariate binary logistic regression was employed to identify independent predictors of the primary composite outcome, incorporating variables with a p-value of <0.1 on univariate analysis as candidate predictors. Results were expressed as adjusted odds ratios (OR) with 95% confidence intervals (CI). A two-tailed p-value of <0.05 was considered statistically significant throughout.

3. RESULTS

3.1 Baseline Characteristics

A total of 95 patients with unstable pelvic fractures were included in the analysis: 52 (54.7%) in the early fixation group and 43 (45.3%) in the delayed fixation group. The mean age of the cohort was 37.2 ± 13.4 years, with a male predominance (73.7%). Road traffic accidents were the predominant mechanism, accounting for 81.1% of cases. The two groups were comparable in terms of age, sex, mechanism of injury, ISS, initial vital signs, haemoglobin, GCS, and fracture type distribution (Table 1), confirming baseline homogeneity.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Groups

Variable	Early Group ≤24h (n=52)	Delayed Group >24h (n=43)	p-value
Age, years (Mean ± SD)	36.4 ± 12.8	38.1 ± 14.2	0.512
Male sex, n (%)	38 (73.1%)	31 (72.1%)	0.912
ISS (Mean ± SD)	28.6 ± 7.4	30.2 ± 8.1	0.278
Initial SBP mmHg (Mean ± SD)	94.3 ± 18.6	91.7 ± 20.1	0.491
Hemoglobin g/dL (Mean ± SD)	9.8 ± 2.1	9.4 ± 2.4	0.340
GCS score (Mean ± SD)	13.2 ± 2.6	12.8 ± 3.1	0.489
Tile Type B, n (%)	24 (46.2%)	20 (46.5%)	0.973
Tile Type C, n (%)	28 (53.8%)	23 (53.5%)	0.973
Associated injuries, n (%)	34 (65.4%)	30 (69.8%)	0.641
Road traffic accident, n (%)	42 (80.8%)	35 (81.4%)	0.934

ISS = Injury Severity Score; SBP = Systolic Blood Pressure; GCS = Glasgow Coma Scale; SD = Standard Deviation. p-values derived from independent t-test or chi-square test as appropriate.

3.2 Intraoperative Parameters and Transfusion Requirements

Patients in the early fixation group experienced significantly lower intraoperative blood loss and

required fewer transfusions compared with the delayed group. Full details are presented in Table 2. Although operative time did not reach statistical significance, there was a trend toward shorter procedures in the early group.

Table 2. Intraoperative Parameters and Blood Product Requirements

Outcome Variable	Early ≤24h (n=52)	Delayed >24h (n=43)	p-value
Intraoperative Parameters			
Operative time, min (Mean ± SD)	128.4 ± 32.7	141.2 ± 38.5	0.074
Intraoperative blood loss mL (Mean ± SD)	680 ± 210	890 ± 275	0.001
Units of pRBCs transfused (Mean ± SD)	2.8 ± 1.4	4.1 ± 1.9	<0.001
FFP units (Mean ± SD)	1.6 ± 0.9	2.4 ± 1.3	0.002

pRBCs = Packed Red Blood Cells; FFP = Fresh Frozen Plasma; SD = Standard Deviation. *Significant at $p < 0.05$.

3.3 Postoperative Complications, Length of Stay, and Functional Outcomes

The early fixation group demonstrated a significantly lower overall complication rate and superior functional recovery. ICU and hospital lengths of stay were markedly reduced in the early group. Detailed outcomes are presented in Table 3.

Table 3. Postoperative Complications, Hospital Stay, and Functional Outcomes

Outcome Variable	Early ≤24h (n=52)	Delayed >24h (n=43)	p-value
Complications			
Overall complications, n (%)	18 (34.6%)	27 (62.8%)	0.006
Wound infection, n (%)	5 (9.6%)	11 (25.6%)	0.036
Deep vein thrombosis, n (%)	6 (11.5%)	12 (27.9%)	0.040
Pulmonary embolism, n (%)	2 (3.8%)	6 (14.0%)	0.073
Pneumonia, n (%)	4 (7.7%)	9 (20.9%)	0.061
ARDS, n (%)	1 (1.9%)	5 (11.6%)	0.048
Mortality, n (%)	3 (5.8%)	7 (16.3%)	0.094
ICU stay, days (Median [IQR])	4 [2–7]	8 [5–13]	<0.001
Hospital LOS, days (Median [IQR])	12 [9–17]	19 [14–26]	<0.001
Functional score (Majeed) at 6 months (Mean ± SD)	74.2 ± 10.6	61.8 ± 13.4	<0.001
Return to work at 6 months, n (%)	33 (63.5%)	18 (41.9%)	0.037

LOS = Length of Stay; ICU = Intensive Care Unit; IQR = Interquartile Range; ARDS = Acute Respiratory Distress Syndrome. Majeed Pelvic Outcome Score range: 0–100 (higher = better). *Significant at $p < 0.05$.

3.4 Independent Predictors of Complications: Multivariate Analysis

On multivariate logistic regression, delayed fixation (>24 hours) emerged as the strongest independent predictor of overall postoperative complications after adjusting for ISS, fracture type, age, associated abdominal injury, and admission haemoglobin level. Table 4 presents the adjusted odds ratios and 95% confidence intervals.

Table 4. Multivariate Logistic Regression: Independent Predictors of Postoperative Complications

Predictor Variable	Adjusted OR	95% CI	p-value
Delayed fixation (>24h)	3.21	1.48–6.97	0.003
ISS ≥ 30	2.87	1.22–6.74	0.016
Tile Type C fracture	2.44	1.09–5.47	0.030
Age ≥ 45 years	1.98	0.88–4.44	0.098
Associated abdominal injury	2.16	0.96–4.86	0.063
Initial hemoglobin < 8 g/dL	2.53	1.11–5.76	0.027

OR = Odds Ratio; CI = Confidence Interval. Reference category: early fixation (≤24h), Tile Type B, age < 45 years, haemoglobin ≥ 8 g/dL. Model Hosmer-Lemeshow goodness-of-fit: p = 0.412.

4. DISCUSSION

This retrospective cohort study demonstrates a clinically and statistically significant association between early definitive surgical fixation of unstable pelvic fractures—within 24 hours of injury—and superior clinical outcomes across multiple dimensions including intraoperative haemostasis, postoperative complication rates, length of hospital and ICU stay, and six-month functional recovery. The finding that delayed fixation carries an adjusted odds ratio of 3.21 for overall postoperative complications represents a clinically meaningful effect size and corroborates a growing body of international evidence supporting timely orthopaedic intervention in haemodynamically stabilised pelvic trauma patients.

The haemostatic advantage of early surgical stabilisation observed in this study is mechanistically coherent. Pelvic ring disruption enlarges the true pelvic volume, undermining the tamponade effect of the retroperitoneal fascial envelope on venous haemorrhage originating from the presacral venous plexus and cancellous bone surfaces [19]. Early reduction and fixation restores pelvic ring geometry, mechanically compresses bleeding surfaces, and reduces the raw bony area contributing to ongoing haematoma expansion [15]. The reduction in intraoperative blood loss—from a mean of 890 mL in the delayed group to 680 mL in the early group—and the corresponding reduction in pRBC and FFP transfusion requirements are consistent with findings reported by Vallier et al. [12], who observed analogous haemostatic benefits in a US Level I trauma centre cohort. The transfusion burden carries its own independent risk, as each unit of allogeneic pRBCs is associated with increased rates of infectious complications, immunomodulation, and acute lung injury [32].

The lower overall complication rate in the early fixation group (34.6% vs. 62.8%) is arguably the most consequential finding of this study. Wound infection, DVT, and ARDS each reached or approached statistical significance as individual events, suggesting that the composite reduction reflects a genuine underlying biological phenomenon rather than a statistical artefact of composite endpoint construction. The inflammatory and prothrombotic milieu established by ongoing haemorrhage, tissue ischaemia, and prolonged recumbency in the delayed group plausibly explains the excess of both infectious and thromboembolic events [31]. Hildebrand et al. [31] characterised the cytokine environment of the post-injury period in detail, demonstrating that IL-6, TNF-α, and IL-10 levels peak within 24 to 48 hours and decline thereafter, suggesting that operative intervention during this window—rather than after—may attenuate the pro-inflammatory stimulus by removing the ongoing mechanical and haemorrhagic irritant.

The reduction in ICU stay (median 4 vs. 8 days) and total hospital stay (median 12 vs. 19 days) observed in the early fixation group carries substantial implications for healthcare resource utilisation, particularly in the context of Baghdad's chronically overstretched hospital system. Prolonged ICU occupation by pelvic trauma patients with avoidable complications imposes opportunity costs on other critically ill patients and contributes to healthcare-associated infections. Scalea et al. [30] and Rixen et al. [29] demonstrated that early skeletal stabilisation—even in the form of temporary external fixation—facilitates nursing care, reduces pulmonary complications by enabling repositioning and upright positioning, and shortens ICU dependency. The functional recovery advantage measured by the Majeed Score at six months (74.2 vs. 61.8 points) is particularly noteworthy, as it reflects patient-centred outcomes beyond the perioperative period. Pohlemann et al. [2] originally validated this instrument and demonstrated that anatomical reduction quality was the strongest radiographic predictor of long-term Majeed scores. The superior functional scores in the early fixation group in our study may thus reflect both timelier mechanical stability—permitting earlier physiotherapy—and better reduction quality achieved in a less inflammatory, less oedematous operative field.

The multivariate analysis identified, alongside delayed fixation, an ISS of ≥30 (adjusted OR 2.87), Tile Type C fracture pattern (adjusted OR 2.44), and initial haemoglobin below 8 g/dL (adjusted OR 2.53) as independent predictors of complications. These findings are clinically intuitive and consistent with the existing literature. ISS ≥30 has been repeatedly identified as a threshold above which systemic physiological reserve is substantially compromised, limiting the body's ability to mount an effective immunological response to surgical stress [13,36]. Tile Type C injuries are characterised by complete pelvic ring instability through both the anterior and posterior arches, resulting in greater rotational and vertical displacement, larger haematoma volumes, and more complex reconstructive requirements [1,3]. The association of low admission haemoglobin with complications likely captures both the severity of haemorrhage at presentation and the impaired tissue oxygen delivery that predisposes to organ dysfunction and impaired wound healing.

It is important to contextualise these findings within the specific realities of pelvic trauma management at a Private Hospital and in Iraq more broadly. Unlike many European and North American trauma centres where pre-hospital times are short and multidisciplinary trauma team activations are standardised, the Iraqi trauma system faces significant challenges including variable ambulance response capability, prolonged transfer times from district hospitals and conflict-affected zones, limited 24-hour interventional radiology capacity, and blood banking constraints that may necessitate conservative preoperative transfusion strategies [39]. These systemic factors account for a proportion of the delays observed in the delayed fixation group and underscore the importance of not extrapolating causality uncritically from this observational dataset. Demetriades et al. [40] and O'Brien et al. [39] both highlighted the compounding effect of systemic healthcare infrastructure on trauma outcomes, independent of surgical decision-making, and similar considerations apply in the Baghdad context.

The damage control orthopaedics philosophy, originally described by Rotondo et al. [33] in the context of penetrating abdominal trauma and subsequently adapted for musculoskeletal injuries by Scalea et al. [30] and Stahel et al. [34], advocates staged management with temporary external fixation followed by delayed definitive reconstruction once the 'lethal triad' of hypothermia, acidosis, and coagulopathy has been corrected. In this study, 19 of 43 patients (44.2%) in the delayed group had undergone prior temporary external fixation as a bridge procedure, which may have contributed to haemostatic control during the delay interval. However, even accounting for this bridging intervention, the delayed group still demonstrated significantly worse outcomes, suggesting that the conversion to definitive fixation should be pursued as expeditiously as patient physiology permits. Pape et al. [28] described the 'borderline patient' concept as a framework for navigating this decision—advocating serial lactate measurements, coagulation profiles, and temperature-corrected base deficit as objective physiological triggers for transition from damage control to definitive care—and a similar protocol-driven approach would be feasible and beneficial at a Private Hospital.

The strengths of this study include its specific focus on a neglected geographical and institutional

context, the use of a validated functional outcome instrument (Majeed Score) with a six-month follow-up horizon, and the comprehensive collection of both intraoperative and postoperative data. The multivariate analysis adjusted for key confounders, reducing but not eliminating the risk of residual confounding inherent to retrospective observational designs. The sample size of 95 patients, while modest by the standards of large registry studies such as those conducted by Holstein et al. [36] in Germany or Sathy et al. [38] in the United States, is representative of the institutional volume achievable over five years in a single private hospital in Baghdad and provides sufficient power to detect clinically meaningful differences in the primary outcome.

Several limitations must be acknowledged. The retrospective design introduces the risk of selection bias and residual confounding. Specifically, the allocation to early versus delayed fixation groups was not randomised but was driven by a combination of clinical judgement, haemodynamic stability, logistical factors (including after-hours operating room availability and blood bank capacity), and the volume of competing emergency procedures. It is conceivable that patients selected for early fixation were systematically less physiologically compromised—despite comparable baseline characteristics—resulting in overestimation of the benefit attributable to timing alone. Additionally, the study was conducted at a single institution, limiting external generalisability to other Iraqi hospitals with different patient volumes, surgical expertise, and resource endowments. The ISS, while a widely used injury severity index, does not capture the nuanced haemodynamic trajectory of individual patients, and the absence of serial lactate or base deficit data limits the physiological characterisation of the study population. Finally, functional outcomes at six months, while meaningful, may not capture the full trajectory of long-term recovery, and future prospective studies with two-year follow-up assessments would provide a more complete picture of functional restoration.

Future research priorities in this domain should include a prospective multicentre cohort study across Baghdad's public and private trauma hospitals, incorporating standardised data collection protocols, validated physiological scoring, and long-term functional follow-up. Such a study would more rigorously address the causal relationship between fixation timing and outcomes, enable subgroup analyses by fracture type and mechanism, and provide the quality of evidence needed to develop national pelvic trauma guidelines tailored to Iraq's healthcare context. There is also an urgent need to evaluate the impact of targeted institutional interventions—such as dedicated pelvic trauma pathways, 24-hour fluoroscopy availability, and pre-hospital triage protocols—on the proportion of patients achieving early definitive fixation.

In conclusion, this study provides evidence from a private hospital that early definitive surgical fixation of unstable pelvic fractures within 24 hours is independently associated with reduced intraoperative blood loss, lower transfusion requirements, fewer postoperative complications, shorter hospital and ICU stays, and superior six-month functional outcomes. While the results must be interpreted in light of the study's inherent limitations, they support the prioritisation of timely stabilisation in haemodynamically resuscitated patients and the development of institutional protocols to facilitate early operative intervention for this complex and life-threatening injury pattern.

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