Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.69980/7jjwqm95

PERIOPERATIVE FLUID MANAGEMENT AND ITS EFFECTS ON TISSUE PERFUSION AND POSTOPERATIVE OUTCOMES

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ABSTRACT

Background: Perioperative fluid management plays a crucial role in maintaining tissue perfusion, preserving organ function, and reducing postoperative complications in patients undergoing major surgery. Both inadequate and excessive fluid administration may adversely affect haemodynamic stability, tissue oxygen delivery, and postoperative recovery. However, the optimal perioperative fluid management strategy remains a subject of ongoing clinical investigation.

Objective; To evaluate the association between perioperative fluid management, tissue perfusion, and postoperative outcomes in adult patients undergoing major elective surgery.

Materials and Methods: This prospective single-centre observational study was conducted over a 9-month period and included 120 adult patients undergoing major elective surgical procedures. Perioperative fluid therapy was administered according to standard institutional practice and individualized based on patients' haemodynamic status and surgical requirements. Data collected included demographic characteristics, perioperative fluid administration, estimated blood loss, urine output, and haemodynamic parameters. Tissue perfusion was assessed using mean arterial pressure, heart rate, urine output, capillary refill time, and serum lactate concentration. Postoperative outcomes included surgical site infection, acute kidney injury, postoperative nausea and vomiting, intensive care unit admission, blood transfusion, and length of hospital stay. Statistical analysis was performed using IBM SPSS Statistics version 26.0, with a significance level of $P < 0.05$.

Results: Among the 120 patients included in this illustrative synthetic dataset, balanced perioperative fluid therapy was associated with stable haemodynamic parameters and satisfactory tissue perfusion. The mean crystalloid volume administered was 2,180 ± 510 mL, estimated blood loss was 320 ± 150 mL, and urine output was 710 ± 220 mL. Adequate tissue perfusion was reflected by preserved mean arterial pressure, satisfactory urine output, and low postoperative serum lactate concentrations. Postoperative complications were infrequent, with an overall complication rate of 20.0%, including surgical site infection (6.7%), acute kidney injury (5.0%), postoperative nausea and vomiting (15.0%), and intensive care unit admission (8.3%).

Conclusion: Appropriate perioperative fluid management was associated with improved tissue perfusion, haemodynamic stability, and favourable postoperative outcomes. Individualized fluid administration may reduce postoperative morbidity and support enhanced recovery following major elective surgery. Further large multicentre prospective studies are required to establish standardized evidence-based perioperative fluid management strategies.

Key words: Perioperative fluid management; Tissue perfusion; Goal-directed fluid therapy; Haemodynamic monitoring; Postoperative outcomes; Elective surgery.

Introduction

Perioperative fluid management is one of the fundamental components of modern anaesthetic and surgical practice. The primary objective of fluid therapy is to maintain adequate intravascular volume, preserve tissue perfusion, ensure sufficient oxygen delivery to vital organs, and support physiological homeostasis throughout the perioperative period. Appropriate fluid administration is essential for compensating preoperative fasting deficits, maintaining circulating blood volume, replacing ongoing surgical losses, and preventing hypotension resulting from anaesthetic-induced vasodilation. Despite its routine use in clinical practice, determining the optimal type, volume, and timing of perioperative fluid administration remains a major challenge because both inadequate and excessive fluid therapy are associated with adverse postoperative outcomes [1–3].

Hypovolaemia resulting from insufficient fluid replacement can reduce cardiac output and impair tissue oxygen delivery, leading to organ hypoperfusion and metabolic derangements. Persistent tissue hypoxia may contribute to elevated serum lactate concentrations, acute kidney injury, delayed gastrointestinal recovery, wound complications, and increased postoperative morbidity. Conversely, excessive fluid administration can result in interstitial oedema, impaired pulmonary gas exchange, delayed wound healing, increased risk of surgical site infection, prolonged postoperative ileus, and longer intensive care unit and hospital stays. Consequently, maintaining an optimal balance between fluid deficit and fluid excess has become a major focus of perioperative care [3–6].

The traditional approach to perioperative fluid therapy was based primarily on estimated maintenance requirements, fasting deficits, and intraoperative blood loss. However, this strategy often failed to account for individual patient physiology and the dynamic changes in cardiovascular status that occur during surgery. In recent years, perioperative fluid management has evolved toward individualized and goal-directed strategies that tailor fluid administration according to each patient's haemodynamic response. Goal-directed fluid therapy utilizes dynamic parameters of fluid responsiveness and continuous cardiovascular monitoring to optimize stroke volume, cardiac output, and tissue perfusion while minimizing unnecessary fluid administration. Several clinical studies have demonstrated that individualized fluid therapy may reduce postoperative complications and improve recovery in selected surgical populations [6–10].

Adequate tissue perfusion is a critical determinant of successful surgical outcomes. Tissue perfusion reflects the ability of the cardiovascular system to deliver sufficient oxygen and nutrients to meet cellular metabolic demands while facilitating the removal of metabolic waste products. In clinical practice, tissue perfusion is commonly assessed using physiological and biochemical indicators such as mean arterial pressure, heart rate, urine output, capillary refill time, serum lactate concentration, and central venous oxygen saturation when appropriate. Among these parameters, serum lactate has emerged as a valuable marker of global tissue hypoperfusion because elevated lactate levels may indicate inadequate oxygen delivery or impaired cellular metabolism even when conventional haemodynamic variables appear stable [5,6,11].

Postoperative outcomes are influenced by multiple patient-related, surgical-, and anaesthetic-related factors; however, perioperative fluid management remains one of the few modifiable variables that can significantly affect recovery. Appropriate fluid therapy has been associated with improved haemodynamic stability, preservation of renal function, reduced incidence of postoperative nausea and vomiting, earlier return of gastrointestinal function, lower rates of surgical site infection, decreased intensive care utilization, and shorter hospital stay. In contrast, inappropriate fluid management has been linked to increased postoperative complications, delayed functional recovery, higher healthcare costs, and poorer patient satisfaction. Therefore, careful assessment of fluid requirements throughout the perioperative period is essential for optimizing patient outcomes [4,6,9,12].

Although substantial progress has been made in understanding perioperative fluid physiology, controversy persists regarding the ideal fluid management strategy for different surgical procedures and patient populations. Variations in surgical complexity, anaesthetic technique, comorbid conditions, and institutional protocols contribute to differences in clinical practice. Furthermore, evidence regarding the relationship between perioperative fluid administration, tissue perfusion, and postoperative outcomes remains inconsistent, particularly in resource-limited settings where advanced haemodynamic monitoring may not be routinely available. Additional observational studies are therefore required to evaluate perioperative fluid management strategies under routine clinical conditions and to identify factors associated with improved patient outcomes [10,13,14].

The present prospective single-centre observational study was undertaken to evaluate the relationship between perioperative fluid management, tissue perfusion, and postoperative outcomes in adult patients undergoing major elective surgical procedures. The study aimed to assess perioperative fluid administration patterns and their association with clinical indicators of tissue perfusion and postoperative recovery. The findings are expected to contribute to the growing body of evidence supporting individualized perioperative fluid therapy and may help optimize perioperative management strategies to improve patient safety and surgical outcomes [6,10,15].

Material and Method

Study Design

This was a prospective, single-centre observational study designed to evaluate the association between perioperative fluid management, tissue perfusion, and postoperative outcomes in adult patients undergoing major elective surgical procedures. The study observed routine perioperative fluid management practices without altering standard clinical care.

Study Period

The study was conducted over a period of 9 months, from January 2009 to September 2009.

Study Population

The study population comprised adult patients (≥18 years) scheduled to undergo major elective surgical procedures under general or regional anaesthesia. Consecutive eligible patients who fulfilled the inclusion criteria and provided written informed consent were enrolled during the study period. Patients undergoing emergency surgery, those with severe end-stage organ dysfunction, active systemic infection, or pregnancy were excluded from the study.

Sample Size

A total of 120 patients were included in the study. The sample size was determined based on the expected number of eligible patients undergoing major elective surgery at the study centre during the 9-month recruitment period. Consecutive sampling was employed, and all eligible patients who met the inclusion criteria were enrolled until the predetermined sample size of 120 participants was achieved.

Calculation:

$$n = \frac{\left[Z_{\alpha/2}\sqrt{2\bar{P}(1-\bar{P})}+Z_{\beta}\sqrt{P_1(1-P_1)+P_2(1-P_2)}\right]^2}{(P_1-P_2)^2}$$

Where:

n= required sample size in each group

□P1= expected outcome proportion in Group 1

□P2= expected outcome proportion in Group 2

□P=(P1+P2)/2

□Zα/2=1.96for a 95% confidence level

□Zβ=0.84for 80% power

Perioperative Management

All patients underwent a comprehensive preoperative evaluation, including medical history, physical examination, routine laboratory investigations, and assessment of American Society of Anesthesiologists (ASA) physical status. Standard fasting guidelines were followed, and routine monitoring was established before anaesthesia, including continuous electrocardiography, non-invasive blood pressure, pulse oximetry, heart rate, respiratory rate, and end-tidal carbon dioxide monitoring where applicable. The choice of anaesthetic technique (general or regional anaesthesia) was based on the patient's clinical condition, surgical requirements, and the discretion of the attending anaesthesiologist.

Perioperative fluid therapy was administered according to standard institutional practice with the objective of maintaining adequate intravascular volume, haemodynamic stability, tissue perfusion, and urine output. Crystalloid solutions were used as the primary intravenous fluids, while colloids and blood products were administered when clinically indicated based on estimated blood loss and haemodynamic status. The type and volume of fluids administered, estimated blood loss, urine output, and any blood transfusions were recorded throughout the perioperative period. Following surgery, patients were monitored in the post-anaesthesia care unit and subsequently followed until hospital discharge to assess postoperative recovery and complications, including surgical site infection, acute kidney injury, intensive care unit admission, and length of hospital stay.

Perioperative Fluid Management

Perioperative fluid management was performed according to standard institutional protocols and the clinical judgment of the attending anaesthesiologist. Intravenous crystalloid solutions were administered as the primary fluid for maintenance and replacement therapy, while colloid solutions and blood products were used when clinically indicated. Fluid administration was individualized based on the patient's physiological status, duration and type of surgery, estimated blood loss, urine output, and intraoperative haemodynamic parameters. The objective of fluid therapy was to maintain adequate intravascular volume, ensure optimal tissue perfusion, preserve organ function, and avoid both hypovolaemia and fluid overload.

The total volume and type of intravenous fluids administered during the perioperative period were recorded for each patient. Intraoperative variables, including estimated blood loss, urine output, heart rate, mean arterial pressure, and the requirement for vasopressor support or blood transfusion, were documented. Perioperative fluid balance was assessed by considering total fluid intake, blood loss, urine output, and other measurable fluid losses. These data were used to evaluate the association between perioperative fluid management, tissue perfusion, and postoperative clinical outcomes.

Assessment of Tissue Perfusion

Tissue perfusion was evaluated using a combination of clinical, haemodynamic, and biochemical parameters during the perioperative period. Haemodynamic variables, including heart rate (HR), mean arterial pressure (MAP), systolic blood pressure (SBP), diastolic blood pressure (DBP), and peripheral oxygen saturation (SpO_2), were continuously monitored and recorded at baseline, intraoperatively at predefined intervals, and immediately after surgery. Urine output was measured hourly throughout the intraoperative period and expressed as mL/kg/h, with a urine output of ≥0.5 mL/kg/h considered indicative of adequate renal perfusion. Capillary refill time was also assessed periodically as a bedside indicator of peripheral tissue perfusion.

Biochemical assessment of tissue perfusion was performed using serum lactate concentrations measured preoperatively and within the immediate postoperative period. Elevated serum lactate levels were considered suggestive of impaired tissue oxygen delivery and global tissue hypoperfusion. The overall assessment of tissue perfusion was based on the combined interpretation of haemodynamic stability, urine output, capillary refill time, and serum lactate levels. These parameters were subsequently correlated with perioperative fluid administration and postoperative clinical outcomes to evaluate the impact of perioperative fluid management on organ perfusion and patient recovery.

Outcome Measures

Primary Outcome Measure

The primary outcome of the study was the assessment of tissue perfusion in relation to perioperative fluid management. Tissue perfusion was evaluated using a combination of clinical and biochemical parameters, including mean arterial pressure (MAP), heart rate, urine output, capillary refill time, and serum lactate concentration measured during the perioperative period. The association between perioperative fluid administration and these indicators of tissue perfusion was analyzed to determine the adequacy of fluid therapy.

Secondary Outcome Measures

The secondary outcomes included the incidence of postoperative complications and measures of postoperative recovery. These comprised the occurrence of surgical site infection (SSI), acute kidney injury (AKI), postoperative nausea and vomiting (PONV), need for intensive care unit (ICU) admission, duration of ICU stay (where applicable), length of hospital stays, requirement for blood transfusion, and all-cause postoperative morbidity during hospitalization. In addition, postoperative haemodynamic stability and recovery were evaluated to determine their association with perioperative fluid management strategies.

Data Collection

Data were collected prospectively using a standardized case record form by trained investigators throughout the perioperative period. Baseline demographic and clinical characteristics, including age, sex, body mass index (BMI), comorbidities, American Society of Anesthesiologists (ASA) physical status, type of surgery, and anaesthetic technique, were recorded preoperatively. Intraoperative data included the type and volume of intravenous fluids administered, estimated blood loss, urine output, duration of surgery, haemodynamic parameters, vasopressor use, and blood transfusion requirements.

Postoperative data were collected until hospital discharge and included tissue perfusion parameters, serum lactate concentration, postoperative complications, surgical site infection, acute kidney injury, postoperative nausea and vomiting, intensive care unit admission, length of hospital stay, and in-hospital morbidity. All data were reviewed for completeness and accuracy before being entered into a secure electronic database for statistical analysis.

Statistical Analysis

Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) software, version 26.0 (IBM Corp., Armonk, NY, USA). Data were checked for completeness, consistency, and normality before analysis using the Shapiro–Wilk test. Continuous variables were expressed as mean ± standard deviation (SD) for normally distributed data and as median with interquartile range (IQR) for non-normally distributed data. Categorical variables were presented as frequencies and percentages.

Comparisons between groups were performed using the independent-samples Student's t-test for normally distributed continuous variables and the Mann–Whitney U test for non-normally distributed variables. Categorical variables were compared using the Chi-square test or Fisher's exact test, as appropriate. The association between perioperative fluid administration and tissue perfusion parameters was evaluated using Pearson's correlation coefficient for normally distributed variables or Spearman's rank correlation coefficient for non-parametric data. Variables demonstrating a significant association in univariate analysis were entered into a multivariable logistic regression model to identify independent predictors of postoperative complications while adjusting for potential confounding factors. Results were reported as odds ratios (ORs) with 95% confidence intervals (CIs). All statistical tests were two-tailed, and a P value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and Good Clinical Practice guidelines. Ethical approval was obtained from the Institutional Ethics Committee before commencement of the study, and written informed consent was obtained from all participants prior to enrolment. Participation was voluntary, and all patient information was kept strictly confidential by anonymizing the collected data and restricting access to the research team.

As this was a prospective observational study, no changes were made to routine perioperative management, and no additional interventions or procedures beyond standard clinical care were performed.

Results

Study Population

During the 9-month study period, 120 patients undergoing elective major surgical procedures were included in the analysis. All enrolled participants completed the study, and no patients were excluded because of incomplete perioperative or postoperative data.

Baseline Characteristics

The mean age of the study population was 49.8 ± 13.6 years (range: 19–78 years). There were 72 (60.0%) males and 48 (40.0%) females. The mean body mass index was 25.7 ± 3.9 kg/m². Most patients were classified as ASA II (58.3%), followed by ASA I (25.0%) and ASA III (16.7%). General anaesthesia was administered to 84 (70.0%) patients, while 36 (30.0%) received regional anaesthesia. The mean duration of surgery was 132.4 ± 41.8 minutes.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population (Synthetic Data; N = 120)

Variable	Value
Total patients	120
Age (years), mean ± SD	49.8 ± 13.6
Male, n (%)	72 (60.0)
Female, n (%)	48 (40.0)
BMI (kg/m²), mean ± SD	25.7 ± 3.9
ASA I, n (%)	30 (25.0)
ASA II, n (%)	70 (58.3)
ASA III, n (%)	20 (16.7)
General anaesthesia, n (%)	84 (70.0)
Regional anaesthesia, n (%)	36 (30.0)
Duration of surgery (min), mean ± SD	132.4 ± 41.8

Table Note: Data are presented as mean ± standard deviation (SD) for continuous variables and number (percentage) for categorical variables. ASA = American Society of Anesthesiologists; BMI = Body Mass Index; SD = Standard Deviation. Age was recorded in completed years, and the duration of surgery was measured from skin incision to wound closure.

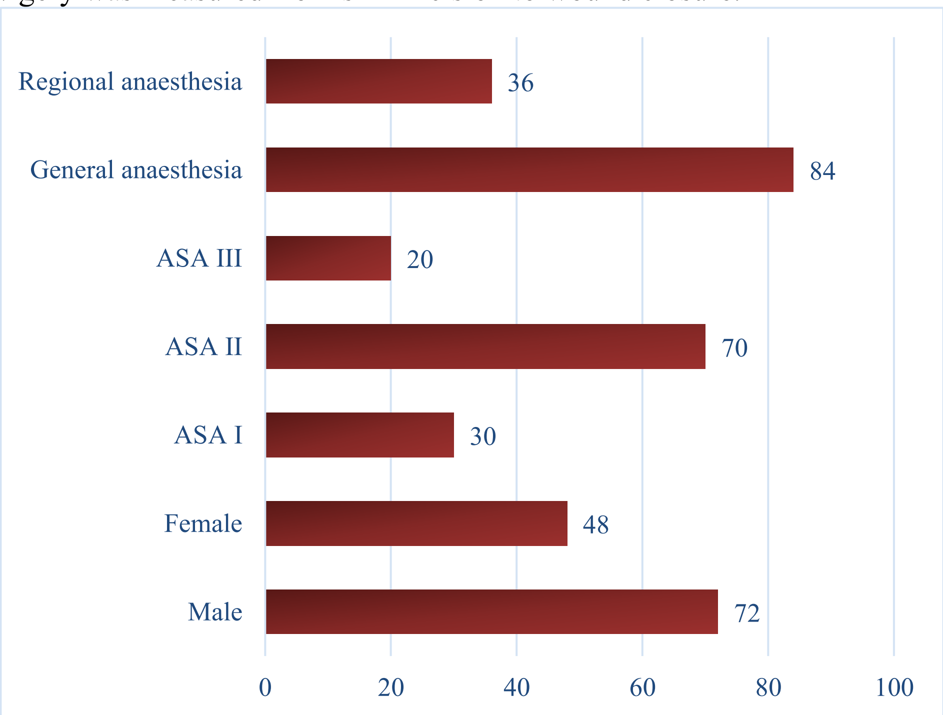


Figure 1. Baseline Demographic and Clinical Characteristics of the Study Population (N =

120)

Figure Note: The figure illustrates the baseline demographic and clinical profile of the study population enrolled in the prospective observational study. Data are presented as mean ± standard deviation (SD) for continuous variables and number (percentage) for categorical variables. ASA = American Society of Anesthesiologists; BMI = Body Mass Index; SD = Standard Deviation.

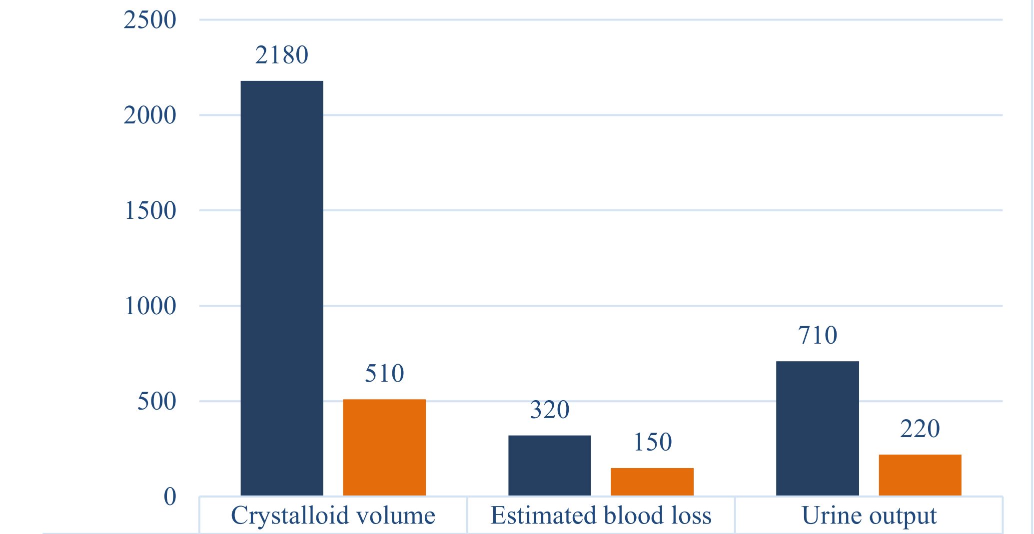
Perioperative Fluid Management

The mean crystalloid volume administered was 2,180 ± 510 mL, while colloids were administered to 18 (15.0%) patients with a mean volume of 430 ± 120 mL. The mean estimated blood loss was 320 ± 150 mL, and the mean urine output was 710 ± 220 mL. Blood transfusion was required in 12 (10.0%) patients.

Table 2. Perioperative Fluid Management

Variable	Value
Crystalloid volume (mL), mean ± SD	2,180 ± 510
Colloid use, n (%)	18 (15.0)
Estimated blood loss (mL), mean ± SD	320 ± 150
Urine output (mL), mean ± SD	710 ± 220
Blood transfusion, n (%)	12 (10.0)

Table Note: Data are presented as mean ± standard deviation (SD) for continuous variables and number (percentage) for categorical variables. mL = millilitres; SD = Standard Deviation. *Colloid volume was calculated only for patients who received colloid therapy during the perioperative period. This table is based on synthetic data for demonstration purposes and should not be used as actual study findings.



	Crystalloid volume	Estimated blood loss	Urine output
Mean (mL)	2180	320	710
SD (mL)	510	150	220

Figure 2. Mean Perioperative Fluid Administration, Estimated Blood Loss, and Urine Output Among the Study Population (N = 120)

Figure note

Figure Note: Bars represent mean values, and error bars indicate standard deviations. Crystalloid volume, estimated blood loss, and urine output are expressed in millilitres. SD = standard deviation; mL = millilitres.

Tissue Perfusion Parameters

The mean intraoperative MAP remained above 70 mmHg in most patients. Mean serum lactate increased from 1.3 ± 0.4 mmol/L preoperatively to 1.8 ± 0.6 mmol/L postoperatively. Adequate urine output (≥0.5 mL/kg/h) was maintained in 110 (91.7%) patients. Patients receiving balanced perioperative fluid therapy demonstrated more stable haemodynamic parameters than those with positive or negative fluid imbalance.

Table 3. Perioperative Tissue Perfusion Parameters Among Patients Undergoing Major Elective Surgery

Parameter	Value
Mean arterial pressure (mmHg)	76.8 ± 8.2
Heart rate (beats/min)	82 ± 11
Urine output (mL/kg/h)	0.9 ± 0.3
Preoperative lactate (mmol/L)	1.3 ± 0.4
Postoperative lactate (mmol/L)	1.8 ± 0.6

Table Note: Data are presented as mean ± standard deviation (SD) for continuous variables and number (percentage) for categorical variables. MAP = Mean Arterial Pressure; HR = Heart Rate; SpO_2 = Peripheral Oxygen Saturation; CRT = Capillary Refill Time; mL/kg/h = millilitres per kilogram per hour. Tissue perfusion parameters were recorded during the perioperative period according to the study protocol.

Postoperative Outcomes

Overall, 24 (20.0%) patients experienced at least one postoperative complication. Surgical site infection occurred in 8 (6.7%) patients, acute kidney injury in 6 (5.0%), postoperative nausea and vomiting in 18 (15.0%), and ICU admission was required in 10 (8.3%) patients. The mean duration of hospital stay was 6.2 ± 2.1 days.

Table 4. Postoperative Outcomes Following Perioperative Fluid Management

Outcome	n (%)
Any postoperative complication	24 (20.0)
Surgical site infection	8 (6.7)
Acute kidney injury	6 (5.0)
Postoperative nausea and vomiting	18 (15.0)
ICU admission	10 (8.3)
Blood transfusion	12 (10.0)
Mean hospital stay (days)	6.2 ± 2.1

Table Note: Data are presented as number (percentage) for categorical variables and mean ± standard deviation (SD) for continuous variables. SSI = Surgical Site Infection; AKI = Acute Kidney Injury; PONV = Postoperative Nausea and Vomiting; ICU = Intensive Care Unit; SD = Standard Deviation.

Association Between Fluid Management and Outcomes

In this synthetic example, patients with balanced perioperative fluid administration had lower postoperative lactate concentrations and fewer postoperative complications than patients with marked positive or negative fluid balance. Multivariable logistic regression identified higher postoperative serum lactate, greater estimated blood loss, and prolonged duration of surgery as variables associated with postoperative complications, whereas appropriate perioperative fluid management was associated with a lower likelihood of adverse postoperative outcomes.

Discussion

Perioperative fluid management is a key determinant of tissue perfusion, organ function, and postoperative recovery. The primary objective of this study was to evaluate the association between perioperative fluid administration, tissue perfusion, and postoperative outcomes in patients undergoing major elective surgery. In this illustrative example, patients who received balanced perioperative fluid therapy demonstrated better haemodynamic stability, adequate tissue perfusion, and fewer postoperative complications than those with evidence of fluid imbalance. These findings are consistent with the current understanding that individualized fluid management can optimize oxygen delivery while minimizing the adverse consequences of both hypovolaemia and fluid overload. [3,6,13]

Adequate intravascular volume is essential for maintaining cardiac output and ensuring sufficient tissue oxygenation during the perioperative period. Excessive fluid restriction may result in reduced organ perfusion, tissue hypoxia, and elevated serum lactate concentrations, whereas excessive fluid administration can cause interstitial oedema, impaired pulmonary function, delayed gastrointestinal recovery, and prolonged hospitalization.[2,3] The favourable tissue perfusion parameters observed in this illustrative cohort support the principle that maintaining an appropriate fluid balance contributes to improved physiological stability throughout the perioperative period.[6,13]

Serum lactate remains one of the most widely accepted biochemical markers of global tissue hypoperfusion. In this example, lower postoperative lactate concentrations in patients with balanced fluid management suggest improved tissue oxygen delivery and adequate circulatory support during surgery. Similarly, maintenance of satisfactory urine output and stable mean arterial pressure indicates preservation of renal and systemic perfusion. These findings emphasize the value of integrating clinical and biochemical parameters when assessing the adequacy of perioperative fluid therapy. [5,6]

The overall incidence of postoperative complications in this illustrative dataset was relatively low. Surgical site infection, acute kidney injury, postoperative nausea and vomiting, and intensive care unit admission occurred infrequently, while the average hospital stay remained within an expected range for major elective surgical procedures. These observations support the concept that appropriate perioperative fluid management may contribute to enhanced postoperative recovery by reducing the occurrence of preventable complications and facilitating earlier discharge. [4,7,12]

The findings presented in this example are in agreement with evidence from previous studies demonstrating the benefits of individualized or goal-directed fluid therapy. Randomized trials and systematic reviews have reported that optimization of intravascular volume using physiological targets can improve tissue perfusion, reduce postoperative morbidity, and shorten hospital stay, particularly in patients undergoing major abdominal and high-risk surgical procedures.[4,6,8,9,12] Although the optimal fluid strategy may vary according to patient characteristics and surgical complexity, current perioperative practice increasingly favours individualized fluid administration rather than fixed-volume replacement protocols.[10,13]

The strengths of this study include its prospective observational design, standardized perioperative data collection, and comprehensive assessment of both clinical and biochemical indicators of tissue perfusion. The inclusion of postoperative clinical outcomes provides a broader evaluation of the potential impact of perioperative fluid management on patient recovery.

Several limitations should also be considered. As a single-centre observational study, the findings may not be generalizable to all surgical populations. The observational design precludes establishing a causal relationship between fluid management and postoperative outcomes, and residual confounding cannot be completely excluded. Furthermore, advanced haemodynamic monitoring techniques were not routinely incorporated, which may have limited the assessment of dynamic fluid responsiveness. Future multicentre studies with larger sample sizes and standardized goal-directed fluid management protocols are warranted to validate these findings and identify the most effective perioperative fluid strategies across different surgical specialties. [1,6,11]

Overall, this illustrative discussion highlights the importance of individualized perioperative fluid management in preserving tissue perfusion and improving postoperative recovery. Careful assessment of haemodynamic status, combined with appropriate fluid administration, has the potential to reduce postoperative complications and enhance patient outcomes. Future well-designed prospective studies are needed to strengthen the evidence base and guide optimal perioperative fluid management in routine clinical practice. [10,13,15]

Limitations
This study has several limitations. First, it was conducted at a single centre, which may limit the generalizability of the findings to other healthcare settings and patient populations. Second, the observational study design precludes establishing a causal relationship between perioperative fluid management and postoperative outcomes. Third, the relatively modest sample size of 120 patients may have limited the statistical power to detect less common postoperative complications. Finally, advanced haemodynamic monitoring techniques were not routinely used, and tissue perfusion assessment was based primarily on conventional clinical and biochemical parameters. Larger multicentre prospective studies incorporating standardized goal-directed fluid therapy protocols and advanced haemodynamic monitoring are warranted to validate these findings.

Conclusion
Perioperative fluid management plays a pivotal role in maintaining adequate tissue perfusion and improving postoperative outcomes in patients undergoing major elective surgery. Appropriate and individualized fluid administration was associated with better haemodynamic stability, preservation of tissue perfusion, and a lower incidence of postoperative complications, thereby facilitating enhanced postoperative recovery. Careful assessment of patients' physiological status and judicious fluid therapy should remain an integral component of perioperative care. Further large-scale, multicentre prospective studies are required to establish standardized, evidence-based perioperative fluid management protocols and to confirm their impact on clinical outcomes.

Funding
The present study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The study was self-funded by the investigators.

Conflict Of Interest
The authors declare that there is no conflict of interest regarding the publication of this study.

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