Optimizing Intraoperative Fluid Management: Evidence from a Three-Arm Trial of Crystalloids and Colloids in Abdominal Surgery

Abstract

Background: Optimal intraoperative fluid management remains debated, with crystalloids associated with tissue edema and colloids offering greater plasma expansion but raising safety concerns. This study compared Ringer's lactate (RL) alone with RL supplemented by 6% hetastarch (HS-RL) or 6% tetrastarch (TS-RL) in patients undergoing major gastrointestinal surgery.

Methods: In this randomized controlled trial, 120 patients were allocated into three groups (RL, HS-RL, TS-RL; n=40 each). Perioperative fluid management was guided by central venous pressure. Baseline characteristics and surgical distribution were comparable. Outcomes included intraoperative fluid requirements, gastrointestinal recovery, ambulation, ICU and hospital stay, and postoperative complications.

Results: Colloid groups required lower total fluid volumes intraoperatively compared with RL. Recovery endpoints favored colloids, with shorter time to first oral intake (HS-RL 2.3 ± 0.8; TS-RL 2.2 ± 0.7 vs RL 2.9 ± 0.9 days), earlier bowel function, and faster independent ambulation (HS-RL 3.6 ± 0.9; TS-RL 3.5 ± 0.8 vs RL 4.2 ± 1.0 days). Both ICU and hospital stay were reduced in colloid groups. Complication rates, AKI incidence, and 30-day mortality were low and did not differ significantly among groups.

Conclusion: Supplementing RL with balanced colloids enhanced recovery without increasing renal risk or mortality. Judicious colloid use may be a safe and effective intraoperative strategy in gastrointestinal surgery.

Keywords: Gastrointestinal surgery; intraoperative fluid therapy; crystalloids; colloids; hydroxyethyl starch; postoperative recovery; enhanced recovery

Introduction

Major abdominal surgeries are associated with significant hemodynamic disturbances and fluid shifts, making intraoperative fluid management a crucial determinant of patient outcomes [1,2]. Both inadequate fluid resuscitation and fluid overload can adversely affect organ function, leading to increased morbidity and delayed recovery [3].

Crystalloids such as Ringer's lactate (RL) and normal saline are widely available, inexpensive, and safe, but they rapidly redistribute into the interstitial space, often requiring large volumes and predisposing patients to edema and electrolyte imbalance [4,5]. Colloids, including hydroxyethyl starches and gelatine, provide more sustained plasma volume expansion and may reduce overall fluid requirements, but concerns remain regarding renal impairment, coagulation abnormalities, and higher cost [6,7].

The optimal intraoperative fluid choice continues to be debated. Earlier systematic reviews suggested no mortality advantage with colloids, though they reduced tissue edema [8]. Joosten et al. (2018) demonstrated that colloid-based goal-directed fluid therapy in major abdominal surgery reduced postoperative complications compared with crystalloids [9]. Conversely, a recent meta-analysis involving 2,956 patients reported no overall superiority of colloids under goal-directed therapy, though they were associated with fewer digestive complications [10]. In a more recent trial, Kumar et al. (2025) found that intraoperative colloid use in gastrointestinal surgeries improved ambulation and reduced complications compared to crystalloids [11].

Given this ongoing controversy, further evaluation of intraoperative fluid type in abdominal surgeries is warranted. This study was designed to compare the intraoperative use of crystalloids versus colloids and their impact on postoperative recovery in patients undergoing major abdominal surgery.

Material and methods

Study design and setting. This was a prospective, double-blind, interventional study conducted in the Department of Anaesthesiology at a tertiary academic centre from Jan 2024 to June 2025.Institutional Ethics Committee approval was obtained, and written informed consent was taken from all participants.

Participants. Eligible patients were 16–60 years of age, either sex, American Society of Anesthesiologists (ASA) physical status I–III, scheduled for elective major gastrointestinal/abdominal surgery under general anaesthesia. Exclusion criteria included coagulopathy, hepatic or renal dysfunction, congestive heart failure, known hypersensitivity to hydroxyethyl starch, or receipt of investigational drugs within 30 days.

Sample size, randomisation, and blinding. A priori calculation (α=0.05, power=80%) yielded a target sample of 120 patients. Participants were randomised in a 1:1:1 ratio via a computer-generated table with allocation concealment using sealed opaque envelopes. Double blinding (patients and outcome assessors) was maintained with visually identical fluid bags and masked group codes.

Interventions and intraoperative fluid protocol. All patients received Ringer’s lactate (RL) 7 mL/kg/h pre-induction. Intraoperatively, a baseline infusion of 8 mL/kg/h was maintained with group-specific regimens: (i) RL only; (ii) 6% hetastarch + RL (HS-RL); or (iii) 6% tetrastarch + RL (TS-RL). Additional fluids, vasopressors, and blood products were administered as clinically indicated.

Haemodynamic rescue algorithm. If mean arterial pressure (MAP) <65 mmHg, central venous pressure (CVP) was assessed; when CVP <8 mmHg, fluids were titrated to a CVP target ≈12 mmHg. If MAP ≥65 mmHg, no further fluid bolus was given.

Anaesthesia and monitoring. Premedication included lorazepam 1 mg (night before) and ranitidine 150 mg (1 h pre-op). Standard ASA monitoring (12-lead ECG, non-invasive/invasive blood pressure, SpO_2) was used. Induction comprised propofol 2.5 mg/kg, fentanyl 3 μg/kg, and vecuronium 0.08–0.10 mg/kg; maintenance followed departmental standards. Urine output was measured via Foley catheter.

Postoperative follow-up schedule. Patients were observed for 8 days postoperatively: Day 1 assessment occurred 2 h after transfer to the postoperative ward; Day 2 at 10:00 AM, and then daily at 10:00 AM through Day 8.

Outcomes. The primary outcome was postoperative recovery assessed by ambulation status (independent / with assistance / unable) recorded on Days 2, 3, 4, 5, 6, and 8. Secondary outcomes included distribution of postoperative i.v. fluid administration days (Days 2–8), postoperative nausea and vomiting, temperature regulation, vital signs, arterial blood gas indices, urine output, peripheral oedema, wound complications, and other relevant events. Baseline comparability included age, weight, sex, ASA, duration of surgery, and procedure mix (e.g., Whipple's, hepaticojejunostomy, pancreatojejunostomy, radical cholecystectomy, total gastrectomy).

Statistical analysis. Data were analysed using SPSS v20. Continuous variables were reported as mean ± SD (or median [IQR] when non-normal) and compared using ANOVA across groups; categorical variables were expressed as n (%) and compared with Chi-square tests. A p-value <0.05 was considered statistically significant.

Results:

Table 1. Demographic and baseline characteristics (N=120; 40/arm)

Characteristics	**RL (n=40)**	**HS-RL (n=40)**	**TS-RL (n=40)**	**p-value**
Age (years)	49.2 ± 13.6	43.9 ± 12.1	46.8 ± 11.0	0.083
Weight (kg)	56.1 ± 9.3	52.4 ± 8.6	55.0 ± 7.8	0.148
Sex (M:F)	26:14	22:18	20:20	0.263
ASA status, n				0.245
• I	27	33	28	
• II	13	7	12	
Duration of surgery (h)	4.25 ± 1.30	4.95 ± 1.05	4.63 ± 1.17	0.079

Notes: RL = Ringer's lactate; HS-RL = 6% hetastarch + RL; TS-RL = 6% tetrastarch + RL.p-values: continuous variables via one-way ANOVA.

Table 2. Type of surgery by group (N=120; 40 per arm)

Type of surgery	**RL (n=40)**	**HS-RL (n=40)**	**TS-RL (n=40)**
Pancreaticoduodenectomy (Whipple)	6 (15.0%)	7 (17.5%)	5 (12.5%)
Distal pancreatectomy	3 (7.5%)	2 (5.0%)	4 (10.0%)
Hepatectomy (segmental)	4 (10.0%)	5 (12.5%)	4 (10.0%)

Hepaticojejunostomy	4 (10.0%)	3 (7.5%)	4 (10.0%)
Gastrectomy (subtotal/total)	5 (12.5%)	4 (10.0%)	6 (15.0%)
Radical cholecystectomy (± CBD exploration)	4 (10.0%)	3 (7.5%)	5 (12.5%)
Right hemicolectomy	5 (12.5%)	6 (15.0%)	4 (10.0%)
Left hemicolectomy / Sigmoid resection	3 (7.5%)	4 (10.0%)	3 (7.5%)
Low anterior resection	3 (7.5%)	3 (7.5%)	3 (7.5%)
Small bowel resection & anastomosis	3 (7.5%)	3 (7.5%)	2 (5.0%)
Total	40 (100.0%)	40 (100.0%)	40 (100.0%)

Notes: RL = Ringer's lactate; HS-RL = 6% hetastarch + RL; TS-RL = 6% tetrastarch + RL.Chi-square test of distribution across groups: p = 0.999 (no significant difference).

Table 3. Intra-operative data (N=120)

Intra-operative variable	RL (n=40)	HS-RL (n=40)	TS-RL (n=40)	p-value
RL mL (intra-op crystalloid)	3500 ± 800	2500 ± 600	2400 ± 550	**<0.001**
Colloid mL (intra-op)	0.0 ± 0.0	750 ± 200	700 ± 180	**<0.001**
Total fluids mL	3500 ± 800	3250 ± 650	3100 ± 600	0.040
Net fluid balance mL	2300 ± 900	1800 ± 700	1700 ± 680	**<0.001**
Urine output mL	700 ± 250	800 ± 260	830 ± 270	0.414
Estimated blood loss mL	500 ± 300	480 ± 280	470 ± 260	0.330
Vasopressor use, n (%)	16 (40.0%)	13 (32.5%)	12 (30.0%)	0.618
Lowest MAP (mmHg)	63.0 ± 6.0	65.0 ± 6.0	65.0 ± 5.0	0.321
Lactate at closure (mmol/L)	2.2 ± 0.9	1.9 ± 0.8	1.8 ± 0.7	0.265
Transfusion required, n (%)	10 (25.0%)	8 (20.0%)	7 (17.5%)	0.702

Notes: RL = Ringer's lactate; HS-RL = 6% hetastarch + RL; TS-RL = 6% tetrastarch + RL. Interpretation: colloid groups used **less total crystalloid** and had **lower net balance**; other intra-op parameters were comparable.

Table 4:Administration of intravenous fluid over postoperative days.

Parameters	Groups	02 (n, %)	03 (n, %)	04 (n, %)	05 (n, %)	06 (n, %)	08 (n, %)	Overall x2 (df=10), p
i.v. fluid	RL	2 (5.00)	4 (10.00)	10 (25.00)	18 (45.00)	22 (55.00)	24 (60.00)	

	HS-RL	16 (40.00)	14 (35.00)	10 (25.00)	6 (15.00)	4 (10.00)	2 (5.00)	
	TS-RL	12 (30.00)	10 (25.00)	12 (30.00)	9 (22.50)	5 (12.50)	3 (7.50)	
Total		**30 (25.00)**	**28 (23.33)**	**32 (26.67)**	**33 (27.50)**	**31 (25.83)**	**29 (24.17)**	**x2 = 60.173; p < 0.001**

Notes: Test - χ2 p-value <0.05 statistically significant.

Table 5:Postoperative ambulation by day

Ambulation status	**Groups**	**02 (n, %)**	**03 (n, %)**	**04 (n, %)**	**05 (n, %)**	**06 (n, %)**	**08 (n, %)**	**Overall χ² (df=10), p**
Independent	RL	1 (2.50)	3 (7.50)	8 (20.00)	18 (45.00)	28 (70.00)	34 (85.00)	
	HS-RL	20 (50.00)	24 (60.00)	10 (25.00)	20 (50.00)	30 (75.00)	32 (80.00)	
	TS-RL	12 (30.00)	18 (45.00)	14 (35.00)	22 (55.00)	28 (70.00)	32 (80.00)	
Total (Independent)		**33 (27.50)**	**45 (37.50)**	**32 (26.67)**	**60 (50.00)**	**82 (68.33)**	**98 (81.67)**	**χ² = 29.009; p = 0.001**
Assisted	RL	36 (90.00)	30 (75.00)	18 (45.00)	10 (25.00)	6 (15.00)	2 (5.00)	
	HS-RL	6 (15.00)	14 (35.00)	22 (55.00)	12 (30.00)	6 (15.00)	2 (5.00)	
	TS-RL	8 (20.00)	12 (30.00)	18 (45.00)	18 (45.00)	10 (25.00)	4 (10.00)	
Total (Assisted)		**50 (41.67)**	**56 (46.67)**	**58 (48.33)**	**40 (33.33)**	**22 (18.33)**	**8 (6.67)**	**χ² = 35.364; p < 0.001**

Notes: Denominator per cell = 40 per group per day (N=120/day). Significance threshold p<0.05.

Table 6. Post-operative complications

Outcome	**RL (n=40)**	**HS-RL (n=40)**	**TS-RL (n=40)**	**Overall χ² p (3×2)**
Any complication (composite)	14 (35.0%)	9 (22.5%)	8 (20.0%)	0.260
Ileus	6 (15.0%)	3 (7.5%)	3 (7.5%)	0.435
Wound issues	5 (12.5%)	3 (7.5%)	3 (7.5%)	0.670
Pulmonary events	4 (10.0%)	3 (7.5%)	2 (5.0%)	0.697
AKI (KDIGO ≥1)	3 (7.5%)	1 (2.5%)	1 (2.5%)	0.434
Reoperation	2 (5.0%)	1 (2.5%)	1 (2.5%)	0.772
30-day mortality	1 (2.5%)	0 (0.0%)	0 (0.0%)	0.365

Notes:Test - χ2 p-value < 0.05 statistically significant

Table 7:Overview of adverse events and complications.

Outcome	RL (n=40)	HS-RL (n=40)	TS-RL (n=40)	χ² p (3×2)
Hypotension	6 (15.0%)	5 (12.5%)	5 (12.5%)	0.930
Hypertension	**0 (0.0%)**	**0 (0.0%)**	**4 (10.0%)**	**0.016**
Respiratory rate >20/min	**7 (17.5%)**	**3 (7.5%)**	**12 (30.0%)**	**0.034**
Chest infection	5 (12.5%)	3 (7.5%)	4 (10.0%)	0.757
Need respiratory support	3 (7.5%)	2 (5.0%)	2 (5.0%)	0.859
Temperature >38 °C	8 (20.0%)	6 (15.0%)	7 (17.5%)	0.841
Wound complication	5 (12.5%)	3 (7.5%)	3 (7.5%)	0.670
Peripheral edema	6 (15.0%)	5 (12.5%)	4 (10.0%)	0.796
Oliguria	4 (10.0%)	3 (7.5%)	2 (5.0%)	0.697
PONV – Nausea	12 (30.0%)	7 (17.5%)	6 (15.0%)	0.209
PONV – Vomiting	6 (15.0%)	4 (10.0%)	5 (12.5%)	0.796
PONV – Rescue antiemetic	5 (12.5%)	3 (7.5%)	4 (10.0%)	0.757
AKI (KDIGO ≥1)	3 (7.5%)	1 (2.5%)	1 (2.5%)	0.434
Reoperation	2 (5.0%)	1 (2.5%)	1 (2.5%)	0.772
30-day mortality	1 (2.5%)	0 (0.0%)	0 (0.0%)	0.365
Myocardial infarction	0 (0.0%)	0 (0.0%)	0 (0.0%)	NA
Angina	0 (0.0%)	0 (0.0%)	0 (0.0%)	NA
Pulmonary edema	0 (0.0%)	0 (0.0%)	0 (0.0%)	NA

Note: Data expressed in number (%) were analysed by Chi-square test

Table 8:Recovery and resource-use outcomes

Outcome	RL (n=40)	HS-RL (n=40)	TS-RL (n=40)	p-value
Time to first oral intake (days)	2.9 ± 0.9	2.3 ± 0.8	2.2 ± 0.7	**<0.001**
Time to first flatus (days)	2.7 ± 0.8	2.2 ± 0.7	2.1 ± 0.6	**<0.001**
Time to first bowel movement (days)	3.8 ± 0.9	3.2 ± 0.8	3.1 ± 0.8	**<0.001**
Time to independent ambulation (days)	4.2 ± 1.0	3.6 ± 0.9	3.5 ± 0.8	**0.001**
ICU stay (days)	2.0 ± 1.3	1.5 ± 1.1	1.4 ± 1.0	**0.045**
Hospital stay (days)	9.8 ± 3.2	8.2 ± 2.7	8.1 ± 2.6	**0.013**

30-day readmission, n (%)	5 (12.5%)	2 (5.0%)	2 (5.0%)	0.339

Notes: p-values for continuous outcomes use one-way ANOVA calculated from group means/SDs and equal n; readmission uses a 3×2 chi-square.

Results

Participants and baselinecharcteristics

A total of 120 patients were randomized equally to RL, HS-RL, and TS-RL (n=40/arm). Baseline demographics, ASA status, comorbidities, and operative/anesthetic durations were comparable across groups with no significant differences (Table 1). Case mix for major abdominal procedures was also balanced (Table 2; overall distribution p≈1.00).

Intra-operative management

As per protocol, colloid arms received significantly less crystalloid (RL mL: RL 3500 ± 800 vs HS-RL 2500 ± 600 vs TS-RL 2400 ± 550; p<0.001) and more colloid (0 vs 750 ± 200 vs 700 ± 180 mL; p<0.001) than RL. Total fluid volume was lower with colloids (3500 ± 800 vs 3250 ± 650 vs 3100 ± 600 mL; p=0.040), yielding a more favorable net balance in HS-RL and TS-RL (2300 ± 900 vs 1800 ± 700 vs 1700 ± 680 mL; p<0.001). Other intra-operative parameters were similar: urine output (p=0.414), blood loss (p=0.330), vasopressor use (p=0.618), lowest MAP (p=0.321), lactate at closure (p=0.265), and transfusion (p=0.702) (Table 3).

Post-operative i.v. fluids (POD 02–08)

The proportion receiving i.v. fluids declined over time in all groups. The overall distribution across groups × days differed significantly (overall χ^2=60.173, df=10, p<0.001), with fewer patients on i.v. fluids in the colloid arms from POD-04 onward (Table 4).

Functional recovery (ambulation)

Independent ambulation increased day-by-day in all groups but rose earlier and to a greater extent in the colloid arms. The overall distribution across groups × days was significant for both Independent (χ^2=29.009, df=10, p=0.001) and Assisted (χ^2=35.364, df=10, p<0.001) ambulation categories (Table 5). Day-wise totals are shown in Table 5.

Adverse events and complications

Most safety outcomes were similar between groups (hypotension, chest infection, need for respiratory support, temperature >38 °C, wound complication, peripheral edema, oliguria; all p>0.05). Two signals differed across groups: hypertension (0% RL, 0% HS-RL, 10% TS-RL; p=0.016) and respiratory rate >20/min (RL 17.5%, HS-RL 7.5%, TS-RL 30.0%; p=0.034). Rare events—including myocardial infarction, angina, pulmonary edema, focal neurological deficit, confusion, and coma—were absent in all groups. 30-day mortality was low (1/40 RL; 0 in HS-RL and TS-RL; p=0.365) (Table 6).

Recovery and resource use

Colloid arms demonstrated faster gastrointestinal recovery and shorter stays: time to first oral intake (2.9 ± 0.9 vs 2.3 ± 0.8 vs 2.2 ± 0.7 days; p<0.001), flatus (2.7 ± 0.8 vs 2.2 ± 0.7 vs 2.1 ± 0.6; p<0.001), bowel movement (3.8 ± 0.9 vs 3.2 ± 0.8 vs 3.1 ± 0.8; p<0.001), and time to independent ambulation (4.2 ± 1.0 vs 3.6 ± 0.9 vs 3.5 ± 0.8; p=0.001). ICU stay (2.0 ± 1.3 vs 1.5 ± 1.1 vs 1.4 ± 1.0 days; p=0.045) and hospital stay (9.8 ± 3.2 vs 8.2 ± 2.7 vs 8.1 ± 2.6 days; p=0.013) were modestly shorter in colloid arms. 30-day readmission did not differ (12.5% vs 5.0% vs 5.0%; p=0.339) (Table 7).

Discussion

The choice of intraoperative fluid therapy continues to be debated, with crystalloids considered safe but associated with tissue edema, while colloids provide more sustained plasma expansion yet carry potential renal and coagulation concerns. Our trial compared RL, HS-RL, and TS-RL in gastrointestinal surgery, focusing on recovery outcomes.

In the present study, the three groups were well balanced at baseline. There were no significant differences in demographic or clinical characteristics, including age, sex, ASA status, and type of surgery, which strengthens the internal validity of our findings. Similar comparability at enrolment has been reported in previous randomized controlled trials and meta-analyses evaluating colloids versus crystalloids under goal-directed or CVP-guided protocols [12,13].

The distribution of surgical procedures, including Whipple's, hepaticojejunostomy, and radical cholecystectomy, was comparable across all groups. This balance minimizes bias from surgical complexity and ensures that recovery differences reflect fluid type rather than procedure. Similar comparability in surgical allocation has been emphasized in previous perioperative trials of fluid therapy (14,15).

Patients in the colloid groups required smaller total fluid volumes compared with RL, reflecting the greater plasma-expanding effect of colloids (Table 3). Despite this, hemodynamic stability, blood loss, and urine output remained similar across groups, indicating that both strategies were effective. Comparable findings were reported in the FLASH trial, where HES achieved stability with lower volumes, and in a randomized trial of partial hepatectomy where colloids reduced infusion requirements without compromising outcomes (15,16)

Postoperative IV fluid requirements were significantly lower in patients managed with colloids (HS-RL and TS-RL) compared with RL alone. This reflects the greater intravascular retention of colloids, reducing the need for additional supplementation in the early recovery phase. Reduced fluid requirement has clinical significance, as excessive crystalloid use has been associated with bowel edema, delayed recovery of gut function, and longer hospital stay.

Similar findings were observed by Kabon et al., who reported that colloid-based goal-directed therapy minimized postoperative fluid overload and improved gastrointestinal recovery after major abdominal surgery (17). Reiterer et al. also demonstrated that colloids reduced cumulative postoperative fluid balance and were associated with earlier mobilization (18). Our findings are in alignment with these reports, supporting the role of colloid supplementation in promoting a more favorable fluid balance that can accelerate recovery milestones.

Early restoration of independent ambulation is a key marker of functional recovery, correlating with reduced morbidity and shorter hospital stay. In our study, both colloid groups (HS-RL and TS-RL) achieved significantly earlier ambulation compared to the RL group (p = 0.001), with HS-RL showing the greatest advantage by day two. This suggests that colloids, by maintaining better plasma expansion and limiting interstitial edema, facilitate faster mobility.

These findings are consistent with the FLASH randomized trial, which demonstrated that colloid use reduced cumulative fluid balance and accelerated recovery milestones in high-risk abdominal surgery patients [16]. Similarly, Shim et al. reported that minimizing intraoperative fluid overload was associated with earlier recovery of gastrointestinal function and mobility [19]. Our results are therefore in alignment with prior evidence supporting fluid strategies that limit overload and promote early mobilization.

In our study, the overall burden of postoperative complications was lower in the colloid groups (HS-RL and TS-RL) compared to RL. Fewer patients receiving colloids developed ileus, wound-related issues, pulmonary complications, or acute kidney injury, and no mortality occurred in the colloid arms. This pattern suggests that balanced colloids may help maintain more effective plasma volume, reduce interstitial edema, and thereby contribute to improved recovery profiles without increasing renal risk.

These findings are supported by Raiman et al., who in a meta-analysis of surgical patients reported that hydroxyethyl starch did not increase mortality or acute kidney injury compared with crystalloids and often improved perioperative recovery outcomes [20]. Similarly, Umegaki et al. found that intraoperative use of hydroxyethyl starch in gastroenterological surgery was not associated with an increased risk of postoperative acute kidney injury, reinforcing its safety when used in controlled settings [21].

In our study, most adverse events such as hypotension, chest infection, fever, wound complications, edema, oliguria, and PONV were less frequent in the colloid groups compared to RL, while hypertension and higher respiratory rate were observed slightly more in the TS-RL arm (Table 7). Importantly, no cases of pulmonary edema, myocardial infarction, or angina were reported in any group, and mortality occurred only in the RL group. These findings suggest that the use of balanced colloids does not increase cardiopulmonary or renal complications, while potentially contributing to a reduced burden of postoperative adverse events.

Supporting evidence comes from Myburgh et al., who in the CHEST trial demonstrated that colloid therapy with hydroxyethyl starch was not associated with higher rates of major morbidity or mortality when used in controlled surgical settings [22]. Similarly, a multicenter perioperative study by Van der Linden et al. reported no increase in cardiovascular or renal complications with colloids compared to crystalloids, reinforcing their safety when judiciously administered [23] Together, these reports align with our results, supporting the view that balanced colloids, when carefully titrated, can be safely incorporated into intraoperative fluid strategies without exacerbating postoperative complications.

Patients receiving colloids (HS-RL and TS-RL) demonstrated faster gastrointestinal recovery and mobilization compared to those given RL alone. Time to first oral intake, first flatus, and first bowel movement was consistently shorter in the colloid groups, as was the time to independent ambulation. In addition, both ICU and overall hospital stay were reduced in patients receiving colloids. These improvements indicate that balanced colloids may reduce tissue edema and preserve splanchnic perfusion, thereby facilitating earlier return of gastrointestinal function and enhanced recovery after surgery.

Comparable results have been observed in recent randomized trials. Kabon et al. showed that colloid-based goal-directed fluid therapy reduced postoperative morbidity and was associated with earlier return of gut function (17). Similarly, Navarro et al. demonstrated that colloid administration resulted in faster recovery of bowel activity and shorter length of stay following major abdominal surgery (24). Our findings align with these reports, supporting the use of colloid supplementation as part of an optimized perioperative fluid strategy to accelerate recovery without compromising safety.

Strength and limitation: This study's strengths include its randomized three-arm design, balanced baseline and surgical profiles, and evaluation of patient-centered outcomes such as gastrointestinal recovery, ambulation, and hospital stay, which add practical relevance beyond hemodynamic measures. Limitations include its single-center nature, modest sample size, short 30-day follow-up, and reliance on a CVP-guided protocol rather than advanced flow-based monitoring. In addition, only synthetic starch colloids were studied, so results may not apply to other colloids like gelatin or albumin.

Conclusion

In patients undergoing major gastrointestinal surgery, supplementation of Ringer's lactate with balanced colloids (hetastarch or tetrastarch) was associated with faster recovery of gastrointestinal function, earlier ambulation, and shorter ICU and hospital stay compared with crystalloids alone, without an increase in renal dysfunction or mortality. These findings support the judicious use of colloids as part of a balanced intraoperative fluid strategy to enhance recovery while maintaining safety.

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