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Original Article

Anaesthesia Section

Practice of Intraoperative Fluid Administration during Major Abdominal Surgeries: A Retrospective Cohort Study at a Tertiary Care Hospital in Southern India

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ABSTRACT

Introduction: Optimal intraoperative fluid therapy can reduce postoperative complications and improve patient outcomes. The Enhanced Recovery After Surgery (ERAS) protocols emphasise fluid restriction. However, the recent randomised clinical trial (RELIEF trial) found a higher incidence of Acute Kidney Injury (AKI) with restrictive fluid therapy. Both excessive and restricted fluid therapy have adverse consequences. Despite various guidelines on perioperative fluid therapy, there is still wide variation in practise.

Aim: To describe the volumes and types of intravenous fluids used during major abdominal surgeries and evaluate the association of intraoperative fluid administration with postoperative complications.

Materials and Methods: This retrospective cohort study was conducted in a multispecialty tertiary care hospital in Thiruvalla, Kerala, India. The study collected data on volumes and types of fluid used in adults undergoing major abdominal surgeries over a one-year period. The incidence of postoperative complications, specifically Postoperative Ileus (POI), Surgical Site Infections (SSI), cardiac complications, and respiratory complications, was noted. The factors affecting intraoperative fluid intake were assessed using the Wilcoxon signed-rank test. Logistic regression was performed to determine associations between preoperative and intraoperative variables and postoperative complications. Adjusted Odds Ratios (OR) and Confidence Intervals (CI) were calculated.

Results: The study included 133 patients with complete data. The mean age of the cohort was 62±18 years, and 69 (52%) patients were males. Patients received a median (IQR) total intraoperative fluid of 3000 (2000-4000) mL with a median infusion rate of 8.77 (6.39-12.35) mL/kg/hr. The majority (132 patients, 99%) received balanced salt solution (ringer lactate) as the main crystalloid. The volume of intravenous fluids infused intraoperatively was significantly greater in emergency surgeries (p-value=0.007), open surgical approaches (p-value <0.001), and surgeries under regional anaesthesia (p-value=0.012). The most common complication in this cohort was POI (38%), which had a significant association with the duration of the surgery (p-value=0.002). Cardiac complications were linked to the volume of intraoperative fluid intake (p-value=0.022), while respiratory complications were predominantly linked to upper abdominal surgeries (p-value=0.049).

Conclusion: The volume of intraoperative fluids administered in major abdominal surgeries varies with the type of surgery (elective versus emergency, open versus laparoscopic) and anaesthesia (regional/general) and significantly impacts patient outcomes after surgery.

Keywords: Crystalloid, Fluid therapy, Ileus, Postoperative complications, Surgical site infection

INTRODUCTION

Perioperative maintenance of adequate intravascular volume status is important to achieve optimal outcomes after surgery. The goal of perioperative fluid therapy is to maintain fluid homeostasis, avoiding fluid excess and organ hypoperfusion. Based on data from a series of clinical trials, the ERAS protocols emphasise avoiding perioperative fluid excess. The goal is to avoid fluid excess, leading to perioperative weight gain of more than 2.5 kg, with a near-zero perioperative fluid balance [1]. However, in a recent randomised clinical trial of high-risk patients undergoing major abdominal surgery (RELIEF trial), patients receiving a restrictive fluid management protocol were found to have a higher incidence of AKI [2]. Thus, both excessive administration and excessive restriction of intravenous fluid are associated with adverse outcomes. Hypovolaemia results in reduced cardiac output and tissue hypoperfusion, while hypervolaemia results in tissue hypoperfusion from tissue oedema, increasing the risk of postoperative respiratory failure and pneumonia, ileus, coagulation abnormalities, impaired wound healing, thereby increasing morbidity, length of hospital stay, and mortality [3]. Regarding the type of fluid, the executive summary of the International Fluid Academy advises balanced salt solutions over normal saline for perioperative fluid therapy as it lowers the chloride load and limits the acid-base alterations [4]. However, despite these guidelines, there is wide variability in fluid administration practise among anaesthesiologists [5].

At present, the intraoperative fluid management strategy at our centre varies widely and is based on the preference of the individual anaesthesiologist managing the case. The aim of this study was to describe the volumes and types of intravenous fluids used during major abdominal surgeries and evaluate the association of intraoperative fluid administration with postoperative complications.

MATERIALS AND METHODS

This was a retrospective cohort study conducted at a 750-bedded multispecialty tertiary care hospital in Thiruvalla, Kerala, India. The study received approval from the Institutional Research and Ethics Committee (IEC/2022/14/58). Data was collected from the hospital's Electronic Medical Records of all adult patients who underwent major abdominal surgery between January 1, 2021, and December 31, 2021. The study was planned, and data collection took place from May to July 2022. The analysis and interpretation of the data were conducted from August to September 2022.

Inclusion criteria: Patients (>18 years of age) belonging to the American Society of Anaesthesiologists-Physical Status class (ASA-PS) I-IV, undergoing major elective or emergency abdominal surgeries, and having an in-hospital postoperative length of stay of more than 24 hours were included in the study.

Exclusion criteria: A preoperative diagnosis of any of the following conditions: sepsis, heart failure (ventricular ejection fraction less than 30%), chronic kidney disease (estimated Glomerular Filtration Rate (eGFR) below 30 mL/min), severe liver disease, or chronic inflammatory disorders requiring long-term steroid therapy were excluded from the study.

Procedure

Besides basic demographic data of patients, the surgical site, surgical approach (open or laparoscopic), type of anaesthesia administered, duration of surgery, as well as volume and type of fluids infused intraoperatively, were also noted. There is no fixed classification of restrictive and liberal fluid strategies, and it varies from study to study. The traditional liberal approach is based on predetermined calculations for presumed preoperative deficits, as well as intraoperative blood and urinary losses, third space loss, and preloading for neuraxial block, which would typically amount to an infusion rate of 10-15 mL/kg/h [6]. The ERAS guidelines recommend a restrictive intraoperative fluid infusion rate of 3±2 mL/kg/h for Gastrointestinal (GI) surgeries [7]. The RELIEF trial, which was a large randomised controlled trial in patients undergoing major abdominal surgeries, defined a maintenance dose of 5 mL/kg/h as restrictive and 8 mL/kg/h as liberal [2]. The final volume infused in the restrictive arm was 6.5 mL/kg/h (IQR 5.1 to 8.4), while that in the liberal arm was 10.9 mL/kg/h (IQR 8.7 to 13.5). Another similar randomised controlled trial used an infusion rate of 4 mL/kg/h for the restrictive arm and 10 mL/kg/h bolus followed by a rate of 12 mL/kg/h for the liberal arm [6]. A large retrospective analysis of fluid infusion practises concluded that a moderately restrictive volume with infusion rates of approximately 6-7 mL/kg/h had the best outcomes [8]. Based on the above data, for the purpose of this study, the fluids infused intraoperatively were expressed as millilitres/kilogram/hour (mL/kg/h) and classified into three groups: 1) restrictive (0-4.9 mL/kg/h); 2) moderately liberal (5.0-9.9 mL/kg/h); 3) liberal (≥10 mL/kg/h).

Outcomes and definitions: The postoperative outcomes noted were the duration of mechanical ventilation (if any), length of Intensive Care Unit (ICU) stay (if any), duration of hospital stay (number of days from the index surgery to discharge), and the occurrence of any complications during the hospital stay. This included respiratory complications (occurrence of pulmonary oedema, the need for reintubation, pneumonia, or respiratory failure), Acute Kidney Injury (AKI), Postoperative Ileus (POI), Surgical Site Infection (SSI), or cardiac complications (including arrhythmias, myocardial ischaemia or infarction).

Postoperative pneumonia is defined as either hospital-acquired pneumonia (pneumonia developing 48-72 hours after admission) or ventilator-associated pneumonia (VAP, pneumonia developing 48-72 hours after endotracheal intubation) occurring in the post-surgical patient, which presents as fever, leucocytosis, increased secretions, and pulmonary infiltrates on chest radiographs [9].

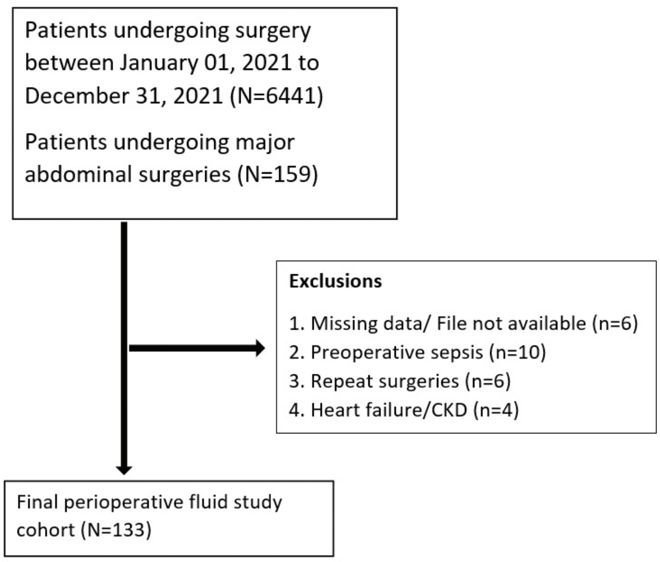
Postoperative respiratory failure is defined as prolonged intubation after surgery (>48 hours) or reintubation after unsuccessful extubation [10]. AKI is defined as an increase in serum creatinine of ≥0.3 mg/dL within 48 hours or ≥50% within seven days, or urine output of <0.5 mL/kg/hour for >6 hours [11]. POI is defined as two or more of nausea/vomiting, inability to tolerate an oral diet over 24 hours, absence of flatus over 24 hours, distension, radiologic confirmation occurring on or after day 4 postoperatively [12]. SSI is defined as an infection related to a surgical procedure that occurs near the surgical site within 30 days following surgery [13]. Postoperative myocardial ischaemia/infarction is defined as the presence of acute myocardial injury detected by abnormal cardiac biomarkers in the setting of evidence of acute myocardial ischaemia [14].

STATISTICAL ANALYSIS

The data were analysed using R version 4.03 (R Core Team, R Foundation for Statistical Computing, Vienna, Austria, 2021). Patient baseline characteristics were summarised using counts and percentages for binary or categorical variables, and means and Standard Deviations (SD) or medians and Interquartile Ranges (IQR) for continuous variables. To statistically compare the factors affecting intraoperative fluid intake, the Wilcoxon signed-rank test was used. The variables included in the test were age, ASA-PS, urgency, duration of surgery, surgical site, surgical approach, type of anaesthesia, and use of vasopressors. The associations between postoperative complications and preoperative and intraoperative variables including age, sex, ASA, total duration of surgery, surgical site, surgical approach, type of anaesthesia, and intraoperative fluid intake were assessed using Odds Ratios (ORs). Logistic regression was performed to adjust for any confounding, and adjusted ORs and Confidence Intervals (CIs) were also calculated.

RESULTS

Complete data was obtained for 133 patients [Table/Fig-1]. The baseline demographics and intraoperative characteristics of the cohort are presented in [Table/Fig-2]. The mean±SD age of the cohort was 62±18 years, and the majority were males (69 patients, 52%). Most patients belonged to ASA class III (75 patients, 56%), and the mean±SD surgical duration was 300±210 minutes. The majority of the surgeries were of the lower GI tract (90 patients, 68%), and they were open (94 patients, 71%). Most patients were administered either General Anaesthesia alone (GA) (53%) or combined with an epidural block (38%).



[Table/Fig-1]: A flow diagram depicting patient selection procedure.

Characteristic	n (%), M±SD
Age (years), Mean±SD	62±18
Sex	
Male	69 (52)
Female	64 (48)
Weight, Mean±SD	63±18
ASA	
I	6 (4.5)
II	49 (37)
III	75 (56)
IV	3 (2.3)

Total duration (minutes), Mean±SD	300±210
Surgical site	
Upper GI and HPB	43 (32)
Lower GI	90 (68)
Surgical approach	
Open	94 (71)
Laparoscopic	39 (29)
Urgency	
Elective	110 (83)
Emergency	23 (17)
Type of anaesthesia	
GA	71 (53.4)
GA+EA	51 (38.3)
CSEB	5 (3.8)
SAB	6 (4.5)
Total intraoperative fluid administered in mL, Median (IQR)	3000 (2000-4000)
Total intraoperative fluid administered in mL/kg/hr, Median (IQR)	8.77 (6.39-12.35)
Intraoperative fluid administered as mL/kg/hour	
Restrictive (0-4.9)	15 (11)
Moderately liberal (5.0-9.9)	67 (50)
Liberal (≥10)	51 (38)
Type of fluid administered Median (IQR)/number of patients (%)	
Balanced salt solution*	2000 (1000-2625)/132 (99%)
Isotonic fluids†	1000 (500-1000)/103 (77%)
Colloids	500 (500-500)/16 (12%)
Blood and blood products	400 (350-750)/26 (20%)

[Table/Fig-2]: Baseline demographics and intraoperative characteristics.
CSEB: Combined spinal epidural anaesthesia; GA: General anaesthesia; GA+EA: General anaesthesia+Epidural anaesthesia; Lower GI: Lower Gastrointestinal; SAB: Subarachnoid block; Upper GI and HPB: Upper gastrointestinal and hepato pancreato biliary
*Balanced salt solution included Ringer lactate, Plasmalyte, Stereofundin
†Isotonic fluids include Normal saline, Dextrose normal saline

The median (IQR) intraoperative fluid administered was 3000 (2000-4000) mL, with a median rate of 8.77 (6.39-12.35) mL/kg/h. Half of the patients (67 patients, 50%) received intraoperative fluids in the moderately liberal range (5.0-9.9 mL/kg/hr), while 51 patients (38%) received fluids in the liberal range (≥ 10 mL/kg/hr), and only 15 patients (11%) received fluids in the restrictive range (0-4.9 mL/kg/hr). The majority of patients (132, 99%) received balanced salt solution (Ringer Lactate, Plasmalyte, or Stereofundin) as the main crystalloid during the intraoperative period, and 77% also received isotonic fluids such as Normal saline or Dextrose normal saline. Around 12% of patients received colloids, while 20% received blood and blood products.

Among the factors affecting intraoperative fluid infusions [Table/Fig-3], emergency compared to elective surgery (median (IQR) of 10.3 (8.1-15.0) vs 8.3 (6.2-11.5), p-value=0.007) and open compared to laparoscopic procedures (9.6 (7.5-12.8) vs 6.3 (4.9-8.5), p-value <0.001) were associated with significantly higher volumes. Also, the use of combined spinal epidural anaesthetic techniques was associated with the highest intraoperative fluid infusion (10.3 (10.0-11.0), p-value=0.012), followed by GA combined with epidural analgesia. The age of the patient, ASA status, duration of surgery, surgical site and the use of vasopressors did not have a significant association with the intraoperative fluid volume infused.

Among the outcomes [Table/Fig-4], the most common postoperative complications noted were POI (51 patients, 38%), followed by SSI (17 patients, 13%). Cardiac complications were seen in six patients (5%); atrial fibrillation in four patients and supraventricular tachycardia in two patients. Four patients (3%) developed postoperative pneumonia. There were no cases of postoperative AKI. Thirty-four patients required postoperative ventilation in the ICU, the majority of whom were extubated the next day (28/34 patients). The average duration of postoperative ICU stay was 1 (0-3) Median (IQR), and the total hospital stay was 8 (6-11) Median (IQR).

Variables		Average fluid infused as mL/kg/hr*	p-value†
Age (years)	<65	8.1 (5.9-12.3)	0.21
	>65	9.0 (6.7-12.)	
ASA	I and II	7.9 (6.3-9.9)	0.11
	III and IV	9.6 (6.7-13.2)	
Urgency	Elective	8.3 (6.2-11.5)	0.007
	Emergency	10.3 (8.1-15.0)	
Duration of surgery	<180 min	9.5 (7.9-13.2)	0.084
	>180 min	8.4 ((5.9-11.9)	
Surgical site	Upper GI and HPB	6.9 (5.3-10.8)	0.09
	Lower GI	9.0 (7.2-12.6)	
Surgical approach	Open	9.6 (7.5-12.8)	<0.001
	Laparoscopic	6.3 (4.9-8.5)	
Type of anaesthesia,	GA	7.6 (5.5-10.7)	0.012
	GA+EA	9.9 (6.9-13.3)	
	CSEB	10.3 (10.0-11.0)	
	SAB	9.7 (9.0-12.2)	
Use of vasopressors	Yes	9.1 (7.4-15.1)	0.15
	No	8.6 (6.3 to 11.9)	

[Table/Fig-3]: Factors affecting intraoperative fluid infusion.
*Median with IQR; †Wilcoxin rank sum test; GI: gastrointestinal; HPB: Hepato-pancreato-biliary

Specific complications	n (%)
Postoperative Ileus (POI)	51 (38)
Surgical Site Infections (SSI)	17 (13)
Respiratory complications	4 (3)
Cardiac complications	6 (5)
Acute Kidney Injury (AKI)	0
Repeat surgery	7 (5)
No. of patients requiring postoperative ventilation	34 (26)
Number of ICU days Median (IQR)	1 (0-3)
Length of hospital stay (days) Median (IQR)	8 (6-11)

[Table/Fig-4]: Outcomes following major abdominal surgeries.

On evaluating the adjusted OR for the outcomes [Table/Fig-5], postoperative cardiac complications were significantly associated with an increased intraoperative fluid intake (OR 1.21 {95% CI: 1.05-1.49}; p-value=0.022), while POI was significantly higher in patients with a prolonged duration of surgery >3 hours (OR 1.01 {95% CI: 1.00-1.01}; p-value=0.002). Also, patients undergoing upper GI and Hepato-Pancreato-Biliary surgeries (HPB) had significantly higher respiratory complications (OR 0.06 {95% CI: 0.00-0.71}; p-value=0.049 with the upper GI+HPB group as reference).

DISCUSSION

The ERAS guidelines for major GI surgeries recommend restrictive fluid therapy or near-zero fluid balance to avoid perioperative weight gain exceeding 2.5 kg [7]. The randomised multicentre RELIEF trial looked at outcomes of liberal versus restrictive fluid infusion therapy in high-risk patients undergoing major abdominal surgeries. They found that restrictive fluid management can lead to AKI as an adverse outcome [2]. The liberal arm in this trial received significantly fewer fluids than the traditional liberal or fixed volume approach. The same authors recommend a moderately liberal IV fluid regimen with an overall positive fluid balance of 1-2 litres at the end of surgery [15]. Goal-Directed Fluid Therapy (GDFT) is recommended in high-risk patients and those undergoing surgeries with major fluid shifts [1,15].

	Postoperative Ileus (POI), N=51		Surgical Site Infections (SSI), N=17		Respiratory complications, N=4		Cardiac complications, N=6	
	Adjusted odds		Adjusted odds		Adjusted odds		Adjusted odds	
Variables	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age	0.98 (0.95 to 1.01)	0.26	1.00 (0.95 to 1.05)	0.97	1.18 (1.02 to 1.50)	0.079	1.11 (1.01 to 1.28)	0.076
Sex								
Male	Reference		Reference		Reference		Reference	
Female	0.38 (0.10 to 1.24)	0.12	0.38 (0.10 to 1.24)	0.12	1.21 (0.53 to 2.80)	0.65	2.59 (0.39 to 23.3)	0.34
ASA	1.77 (0.88 to 3.74)	0.12	0.56 (0.20 to 1.58)	0.27				
Duration of surgery	1.01 (1.00 to 1.01)	**0.002**	1.00 (1.00 to 1.00)	0.83	1.00 (0.99 to 1.01)	0.69	1.00 (1.00 to 1.01)	0.38
Surgical site								
Upper GI and HPB	Reference		Reference		Reference		Reference	
Lower GI	1.82 (0.70 to 5.04)	0.23	9.07 (1.43 to 182)	0.051	0.06 (0.00 to 0.71)	**0.049**	1.70 (0.15 to 49.4)	0.70
Surgical approach								
Open	Reference		Reference		-		-	
Laparoscopic*	0.48 (0.16 to 1.35)	0.17	0.28 (0.01 to 1.96)	0.27	-		-	
Type of anaesthesia								
GA	Reference		Reference		-		-	
GA + EA	0.85 (0.31 to 2.25)	0.75	2.02 (0.50 to 9.04)	0.33	-		-	
CSEB[†]	0.40 (0.02 to 3.29)	0.45	1.84 (0.07 to 23.0)	0.65	-		-	
SAB[†]	3.60 (0.53 to 25.7)	0.18	1.34 (0.06 to 14.9)	0.82	-		-	
Fluid intake	1.00 (0.91 to 1.09)	0.9	0.98 (0.83 to 1.12)	0.79	1.07 (0.75 to 1.39)	0.67	1.21 (1.05 to 1.49)	**0.022**

[Table/Fig-5]: Adjusted Odds Ratio (OR) for postoperative complications.
*No patient who had a laparoscopic procedure developed cardiac or respiratory complications hence OR could not be calculated between cardiac/respiratory complication and surgical approach.
[†]No patient in the CSEB and SAB groups developed cardiac or respiratory complication hence OR could not be calculated between cardiac or respiratory complications and type of anaesthesia.
ASA: American society of anaesthesiologists classification; CSEB: Combined spinal anaesthesia; EA: Epidural anaesthesia; GA: General anaesthesia; GI: Gastrointestinal; HPB: Hepato-pancreato-biliary; SAB: Sub arachnoid block

This study found that the majority (50%) of patients undergoing major abdominal surgeries received moderately liberal volumes (5-10 mL/kg/h) of intraoperative fluids. Another 38% received liberal volumes exceeding 10 mL/kg/h. The volume of intravenous fluids infused intraoperatively was significantly greater in patients undergoing emergency surgeries, open surgical approaches, and following the use of regional anaesthetic techniques such as epidural combined with spinal or general anaesthesia. A similar study among patients undergoing elective GI surgery found that perioperative fluid administration exceeded guidelines, and epidural analgesia was an independent predictor of infused fluid volume [16].

Various large multicentre retrospective studies in patients undergoing non cardiac surgery have shown that patients receiving the highest and lowest quintiles of intravenous fluids are more prone to complications [8,17]. Patients who received liberal fluid volumes had a higher incidence of respiratory complications, while those in the highest and lowest fluid quintiles had a greater odds of developing AKI. They found that a moderately restrictive volume corresponding to intraoperative infusion rates of approximately 6-7 mL/kg/hr was consistently associated with optimal postoperative outcomes [8]. Thus, a fluid management protocol and careful titration of intraoperative fluid therapy based on surgical and patient risk factors will help optimise patient outcomes.

The type of fluid advocated for maintenance in the perioperative period is balanced salt solution, which was the most common type of fluid used among the patients in this study [1,4,15]. Normal saline was used in 103 patients (77%), and the median (IQR) volume infused was 1000 (500-1000). The recent guidelines [1,4] discourage the use of normal saline as it has been implicated in causing dose-dependent acidosis and hyperchloraemia, potentially leading to renal injury [4].

The most common postoperative complications in this cohort were POI, followed by SSIs. There were no cases of AKI. The incidence of POI was associated with the duration of the surgery. An observational study of patients undergoing surgery for colorectal malignancy found a similar association between surgical time >three hours and the occurrence of POI [18]. This correlates with present study, where the mean surgical duration was five hours. Postoperative respiratory complications were linked to upper GI and HPB surgeries. Upper abdominal incisions are the most significant procedural risk factor in predicting the overall risk of postoperative pulmonary complications [19]. Cardiac complications, particularly cardiac dysrhythmias, were linked to higher intraoperative fluid intake in present study. Excessive fluid administration after cardiothoracic surgery has been proposed as a cause of postoperative atrial fibrillation. The mechanism of postoperative atrial fibrillation is thought to be multifactorial, including sympathetic activation, electrophysiological imbalances, metabolic disturbances, hypoxia, and hypervolaemia. Hypervolaemia increases intravascular volume, causing stretching of the right atrium and postulated to cause atrial fibrillation [20]. There was no association between fluid volumes and postoperative respiratory complications, and there were no cases of new onset AKI as a complication postoperatively. This could be due to the small size of this cohort.

This study highlights the factors affecting the volume of intravenous fluids administered in patients undergoing major abdominal surgeries and patterns of fluid administration according to the nature and type of surgery. Although current guidelines emphasise restrictive fluid therapy, clinicians continue to use a liberal range of fluids intraoperatively. Recent studies have shown better outcomes with a moderately restrictive/liberal fluid therapy compared to a restrictive or liberal approach. Protocols need to be adopted and carried out to reduce variability in fluid administration and improve outcomes. A previous meta-analysis emphasised that goal-directed fluid protocols are associated with reduced variability in fluid management and better outcomes [21]. Specific steps to be adopted include lowering maintenance infusion rates intraoperatively, preferably to a moderately liberal fluid transfusion regimen [15], using GDFT when indicated, using balanced salt solutions for maintenance, and timely use of vasopressors to offset the effect of regional anaesthesia.

Limitation(s)

Limitations of the study include a small sample size. The number of patients in the restrictive range of fluid infusion was limited, and therefore there was no association with the monitored outcomes. Data on losses, urine output, and fluid balance were not included as they were not complete for these variables. The study only included intraoperative fluid data and did not extend to the postoperative period.

CONCLUSION(S)

The intraoperative fluid infusion practises at this centre follow a moderately liberal approach. Protocols need to be implemented to reduce variability in fluid administration and improve outcomes. These protocols should include measures to lower maintenance infusion rates intraoperatively, use GDFT when indicated, use balanced salt solutions for maintenance, and timely use of vasopressors to offset the effect of regional anaesthesia.

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EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. No

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