Perioperative Fluid Restriction

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Abstract

Keywords

- colorectal
- bowel surgery
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- mechanical bowel preparation
- enhanced recovery
- outcomes

Perioperative fluid management of the colorectal surgical patient has evolved significantly over the last five decades. Older notions espousing aggressive hydration have been shown to be associated with increased complications. Newer data regarding fluid restriction has shown an association with improved outcomes. Management of perioperative fluid administration can be considered in three primary phases: In the preoperative phase, data suggests that avoidance of preoperative bowel preparation and avoidance of undue preoperative dehydration can improve outcomes. Although the type of intraoperative fluid given does not have a significant effect on outcome, data do suggest that a restrictive fluid regimen results in improved outcomes. Finally, in the postoperative phase of fluid management, a fluid-restrictive regimen, coupled with early enteral feeding also seems to result in improved outcomes.

CME Objectives: After reading this article, the reader should be able to identify some of the controversies regarding perioperative fluid management and the benefits of perioperative fluid restriction.

The debate regarding appropriate perioperative fluid management is an old one. The administration of intravenous fluid saw its introduction into clinical practice in the 19th century first for the treatment of cholera, then later for hemorrhage and shock.^{1,2} Further study in the early 20th century solidified its routine use as an important adjunct in supporting patients in both the intraoperative and postoperative periods. The goal of perioperative fluid management is unambiguous: to ensure adequate intravascular volume to maximize tissue perfusion and optimize outcomes while simultaneously avoiding the sequela of aggressive rehydration, and the resultant interstitial edema, especially given the systemic inflammatory response state induced by major surgery. Historically, the notion of third-spacing was popularized by Shires et al,³ most notably exemplified in the treatment of burn patients. This notion of insensible fluid loss led to an aggressive fluid repletion regimen to avoid the undue loss of intravascular volume. For elective surgery, patients were traditionally admitted preoperatively for bowel preparation and fluid resuscitation preoperatively. In the mid-20th century, these notions began to be challenged, noting deleterious effects of overhydration includ-

ing effects on the pulmonary system in the form of acute respiratory distress syndrome and prolonged postoperative ileus.⁴ Newer data have continued to challenge these notions and practitioners have shifted toward a more fluid-restrictive approach, citing data showing an association with improved postoperative outcomes.

Preoperative Fluid Management

Effective fluid management of the colorectal patient begins well before the operation starts. With the shift toward minimizing length of stay (LOS) and same-day surgery, perturbations in fluid status in the colorectal patient begin with the decision for outpatient bowel preparation. It is well documented that the mechanical bowel preparation (MBP) most patients undergo prior to surgery can result in large volume shifts and preoperative dehydration.⁵ Hypertonic, low-volume bowel preparations have been largely abandoned because of potential risks of nephrotoxicity and dehydration, in favor of isotonic and larger volume preps that were designed to minimize fluid shifts. Furthermore, there is more mounting evidence of not only the lack of need for MBP, but also potential increased complications associated with their use.^{6,7} Meta-analyses have pointed to a possible increase in the risk of wound and other postoperative complications associated with MBP, and some practitioners have

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begun to abandon their use either selectively (for right-sided resections) or altogether.

Emerging data regarding fast-track protocols, which are multimodality practices incorporating many factors designed to minimize postoperative ileus and maximize bowel recovery, incorporate fluid minimization pre- and perioperatively coupled with preoperative carbohydrate loading and early postoperative feeding. One of the key aspects of these protocols involves lack of bowel preparation and the minimization of preoperative fluid administration.^{8,9}

Regardless of the modalities used preoperatively, it is incumbent upon each surgeon to assess the volume status of our patients preoperatively to determine volume status. Our “expert” assessment has been shown to be notoriously faulty based on subjective analysis¹⁰ thus, use of more objective indicators such as standard preoperative laboratory values like hemoglobin level and blood urea nitrogen/creatinine ratio become very important.

This becomes even more important when evaluating patients for more urgent or emergent indications for surgery because we do not have the luxury for a measured preoperative regimen.

Intraoperative Fluid Assessment and Administration

Choice of Intraoperative Fluid

The primary goal of intraoperative fluid administration is to ensure adequate circulating volume, which will in turn ensure adequate tissue perfusion and oxygenation. Although there is currently clear emphasis in the literature on the ideal volume of fluid that should be administered intraoperatively, there has also been considerable controversy about the type of fluid. Broadly, the options are either crystalloids or colloids.

Crystalloid solutions are composed of water and low-molecular solutes, which, depending on the composition, can be hypotonic, isotonic, or hypertonic. These solutions are advantageous because they are inexpensive, easy to store, have a long shelf life, and are readily available. Additionally, crystalloids have a very low incidence of adverse reactions and are effective for use as replacement or maintenance infusion.^{2,4,11,12} Isotonic fluids, such as normal saline and Ringer’s lactate, are generally used for large volume infusions, but only ~20% of the infused volume remains in the vascular compartment. Therefore, large volumes may be required to raise and maintain adequate circulating volume and blood pressure.^{4,12}

Alternatively, colloid solutions (i.e., albumin, hetastarch, dextrans) contain high-molecular-weight molecules allowing them to remain in the intravascular compartment for longer periods. Although this facilitates the infusion of smaller volumes, thereby minimizing the potential for volume overload, colloids are generally more expensive and have been associated with a risk of anaphylaxis and dose-dependent coagulopathy.^{4,12}

In 1999, a systematic review of randomized trials by Choi et al comparing isotonic crystalloid and colloid fluid resuscitation demonstrated that there was no difference in pulmo-

nary edema, mortality, or LOS.² These results have been corroborated by a recent Cochrane Review, which concluded that there is no evidence that resuscitation with colloids reduces the risk of death, compared with resuscitation with crystalloids, in patients with trauma or burns, or in patients following surgery.¹³

Given the available data, it has been common practice to infuse isotonic crystalloids during most elective abdominal procedures, while supplements of colloid fluids are given at the discretion of the anesthesiologist.

Fluid Administration Strategies: Traditional versus Restrictive

In the elective or emergent setting, the intraoperative phase of fluid management generally begins with an assessment of the patient’s overall fluid balance, which can be affected by preoperative fasting and gastrointestinal volume losses, such as a MBP. With a traditional approach, this volume loss is replaced with generous maintenance infusions based on standard formulas. Additional fluid is given after an estimation of blood loss and suspected insensible losses—third spacing and evaporative. To a smaller extent, fluid boluses are also used to compensate for the hypotensive effects of general anesthesia.^{4,14}

There has been emerging data that suggests that this liberal administration of fluid can have a negative impact of patient recovery.^{4,14–20} More attention has been paid to restrictive fluid administration strategies. In the last decade, there have been four randomized controlled trials that have compared these two strategies with varied results (► **Table 1**).

In one earlier study, 56 patients were randomized to conservative (8 mL/kg/h) or aggressive (16–18 mL/kg/h) intraoperative fluid administration. Tissue perfusion and oxygen tension were used as surrogate end points for wound healing. The authors found that an aggressive regimen was associated with significantly greater intraoperative tissue subcutaneous oxygen tension, which was measured with a tissue oxygen sensor that was inserted into the subcutaneous tissue of the upper arm. Although the rate of wound complications was not reported in this study, the authors hypothesized that improved tissue oxygenation would enhance wound healing and reduce the risk of infection.²¹ A follow-up study with 253 patients randomized to the same resuscitation strategies did not demonstrate any significant difference in wound infection rates.²² Another randomized trial of patients undergoing elective colorectal procedures had conflicting results. In this blinded, multicenter study, 172 patients were randomized to the restrictive group receiving almost half of the standard intraoperative volume of fluid—a combination of colloid (hydroxyethyl starch 6% in normal saline) and crystalloid (normal saline). Fluid restrictions were also implemented postoperatively. They found that there were significant differences in both minor and major 30-day complications, including wound and cardiopulmonary complications.¹⁵

The data from these two studies underscore the controversy that still exists on this topic. However, there has been a growing body of literature with reproducible results in

Table 1 Recent randomized trials assessing intraoperative fluid administration with restrictive and liberal strategies

Study	# of patients	Procedures performed	Volume of fluid administered	Type of fluid administered	Primary end point(s)	Result(s)
Arkilic et al (2003) ²¹	56	Elective colon surgery	2.2 L vs. 3.8 L (mean)	Crystalloid	Tissue perfusion & oxygen tension	Liberal regimen increased oxygen tension & tissue perfusion
Brandstrup et al (2003) ¹⁵	172	Elective colon surgery	2.7 L vs. 5.4 L (median)	Colloid and crystalloid	Postoperative complications	Restrictive regimen decreased complications
Nisanevich et al (2005) ²⁰	152	Major intraabdominal surgery	1.4 L vs. 3.9 L (mean)	Crystalloid	Mortality & complications	Restrictive regimen decreased complications. No difference in mortality
Holte et al (2007) ¹⁸	32	Elective colon surgery	1.6 L vs. 5 L (median)	Colloid and crystalloid	Pulmonary function	Restrictive regimen improved pulmonary function

support of a more restrictive approach to fluid administration, especially intraoperatively. It has been difficult to effectively implement this strategy across practices because there are no standardized definitions or end points of resuscitation. Nonetheless, it seems clear that intraoperative fluid assessment and administration should be individualized, taking into account the type and extent of surgery as well as patient comorbidities.¹⁰

Goal-Directed Fluid Administration

Standard monitoring of intraoperative volume status has generally relied on trends in heart rate, blood pressure, and urine output. Alterations in these defined parameters dictate how fluid is administered with the ultimate goal of maximizing tissue perfusion, while avoiding even transient hypovolemia or hypervolemia.²³ Some have argued that these routine measurements can be insensitive indicators of occult changes in intravascular volume, especially with the fixed-volume regimens described previously.^{24,25} This problem has prompted considerable interest in goal-directed fluid therapy, which attempts to administer fluid in a patient-specific manner.

Central venous lines and pulmonary artery catheters are among the tools that have been used in critically ill patients and surgical patients to further aid in cardiovascular monitoring. However, these interventions are invasive and difficult to interpret. Furthermore, they have not been shown to impart any benefit in survival or in length of hospital stay; therefore, their routine use has not been advocated.^{26–28} On the other hand, esophageal Doppler monitoring has been studied extensively and has been shown to be efficacious.

Intraoperatively, a Doppler probe is introduced into the esophagus and aligned with the descending thoracic aorta, allowing measurement of flow velocity. The stroke volume can then be calculated and is maximized intraoperatively with boluses of colloid solutions.²⁹ There have been three meta-analyses of trials utilizing goal-directed management with the esophageal Doppler, which are summarized in ►Table 2.

The two larger trials, comprising patients undergoing elective colorectal surgery, have congruent results.^{30,31} In each study, intraoperative Doppler-guided colloid boluses are compared with a conventional strategy utilizing standard cardiovascular monitoring or central venous pressure measurements. Postoperative care was uniform between groups. The Doppler-guided fluid groups had significantly shorter hospital stays, earlier times to tolerating a regular diet, and fewer overall complications. These positive results have resulted in more widespread use.⁴

To date, there have been no trials comparing goal-directed fluid administration with a restrictive fluid-replacement strategy.

Postoperative Fluid Management

Fluid Restriction in the Postoperative Period

Careful consideration of fluid balance should be an ongoing process especially in the postoperative period as current

Table 2 Meta-analyses of trials utilizing goal directed management with esophageal Doppler monitoring

Study	# of studies (patients)	Procedures performed	Strategies studied	Result(s)
Abbas et al (2008) ²⁴	5 RCT (420 patients)	Major abdominal surgery	EDM vs. conventional fluid replacement	EDM group demonstrated: Reduced length of hospital stay Fewer complications Quicker return of bowel function Greater volumes of colloids administered No difference in mortality
Walsh et al (2008) ³⁹	4 RCT (393 patients)	Major abdominal surgery	EDM vs. conventional fluid replacement	EDM group demonstrated: Reduced length of hospital stay Fewer complications No difference in volumes of fluid administered
Rahbari et al (2009) ³³	3 RCT (288 patients)	Elective colorectal resection	EDM vs. conventional fluid replacement	EDM group demonstrated: Reduced postoperative morbidity No difference in anastomotic failure No difference in mortality

Abbreviations: RCT, randomized controlled trial, EDM, esophageal Doppler monitoring.

liberal strategies can result in significant increases in body weight.^{15,19} Intestinal edema, delayed gastric emptying, wound and cardiopulmonary complications are all recognized manifestations of volume overload.^{15,32,33} Significant efforts should be made to continue to minimize superfluous fluid administration as the patient transitions from the intraoperative phase to the postoperative period after elective colon and rectal surgeries.

Although some trials have failed to show any significant benefit,^{34,35} the greater body of literature supports fluid restriction in the postoperative period as well. Underscoring this point, Lobo et al randomized patients with colon cancer undergoing elective resections to standard (≥ 3 L water and 154 mmol sodium per day) and restrictive fluid regimens (≤ 2 L water and 77 mmol sodium per day). Gastric emptying was measured using a technetium-labeled meal on the fourth postoperative day. They found that the restrictive group had significantly improved liquid and solid gastric emptying as well as shorter hospital stays and earlier return of bowel function.¹⁹

Brandstrup et al also reported on the continuation of fluid restriction in the postoperative period, specifically aimed at unchanged body weight. The combination of intraoperative and postoperative fluid restriction was shown to be associated with fewer cardiopulmonary and wound complications in a dose-dependent manner.¹⁵

Enhanced Recovery Programs

Enhanced recovery or fast-track protocols in colorectal surgery have become increasingly prevalent globally in the past decade. They aim to reduce LOS and associated complications by reducing the physiological stress of surgery and optimizing recovery. These protocols require a multidisciplinary approach, which begins with patient education and incorporates limited use of a MBP, optimal intraoperative and postoperative analgesia, early enteral nutrition, early

mobilization, and judicious fluid administration.^{8,17,18,36,37} As fluid restriction is an integral part of any enhanced recovery protocol, this has been fertile ground for new studies on the subject in the modern era of perioperative care.

Abraham-Nordling et al recently reported a prospective, randomized trial comparing restricted and standard perioperative intravenous fluid regimens in 161 patients undergoing elective colon and rectal surgery embedded in a well-established fast-track protocol. Patients were further stratified for colonic, rectal, open, and laparoscopic surgery. Patients in the restricted group received a median of 3,050-mL fluid on the day of surgery compared with 5,775 mL in the standard group. Oral intake was advanced on the first postoperative day and intravenous fluid discontinued, if feasible. This resulted in less change in body weight in the restricted group. The authors found that there was no significant difference in the LOS or time to return of bowel function between groups. The total number of complications was significantly lower in the restricted group; however, there were more cardiac complications in this group. Although LOS was reduced in the laparoscopic groups, this was not statistically significant. The use of vasopressors was higher during the operation with the restricted group and more of these patients had mild, reversible renal failure in the postoperative period ($p > 0.05$). The authors concluded that restricted perioperative intravenous fluid administration did not reduce LOS in a fast-track protocol. Furthermore, they postulate that restrictive fluid protocols may not be ideal for all patients and a more tailored approach may be appropriate.³⁸

In an attempt to answer this question, Senagore et al published a randomized trial in 2009 comparing goal-directed fluid administration of crystalloid or colloid fluids with standard resuscitation in a cohort of 64 patients undergoing laparoscopic colectomies with an enhanced recovery protocol. The goal-directed colloid group had the longest stay (75.5 h), while the standard group had the shortest LOS (64.9 h)

($p < 0.05$), prompting the conclusion that goal-directed intraoperative fluid management does not confer an advantage within a structured enhanced recovery protocol. The study was not powered to assess complications between the groups, but a higher incidence was noted in the goal-directed colloid group.³⁵

Further study with larger, randomized trials is clearly needed to elucidate this topic further, especially in this period of minimally invasive colorectal surgery. Nonetheless, it has been well established that judicious postoperative fluid restriction, and avoiding hypovolemia and poor end-organ perfusion is an integral part of optimizing recovery.^{8,36}

Summary

The traditional, formulaic approach to fluid administration in the perioperative period is an intensely contested topic, especially with the implementation of enhanced recovery protocols in elective colon and rectal surgery. Although the type of fluid and the methods of monitoring optimal fluid balance are not as clearly defined, the wealth of data currently supports a more restrictive approach. This strategy has been shown to impart significant benefit in the reduction of hospital stay and perioperative complications. It is also important to understand that these studies should be interpreted with care, as "restrictive" protocols are not currently standardized. Further study is needed in this area, as well as in goal-directed, individualized approaches.

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