Fluid management for enhanced recovery surgery

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Abstract: This review article introduces some of the major concepts in perioperative fluid management and the application of these to enhanced recovery programmes (ERPs). The aim of these programmes are to implement multimodal pathways in the perioperative period in order to reduce the risk of perioperative organ dysfunction and morbidity. This article introduces some of the concepts that should be considered during ERPs in terms of perioperative fluid administration, based upon the latest recommendations and guidelines produced internationally. Inappropriate fluid management can lead to increased morbidity, increased length of stay and can have costly implications for healthcare providers. Overall concepts of fluid management include maintenance of homeostasis and euvolaemia. We have looked at how to implement this for patients in preoperative, intraoperative and postoperative states. This article is based upon recent guidelines and consensus statements published internationally. Despite the generalised concepts behind fluid administration in ERPs, patients should continue to have individualised management plans based upon their specific health requirements.

Keywords: Fluid; perioperative; surgery; high risk

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Introduction

Enhanced recovery programmes (ERPs) aim to implement multimodal pathways in the perioperative period to reduce the risk of perioperative organ dysfunction and morbidity through such aims as encouraging early mobilisation. This article introduces some of the concepts that should be considered during ERPs in terms of perioperative fluid administration, based upon the latest recommendations and guidelines produced internationally. Inappropriate fluid management can lead to increased morbidity, increased length of stay and can have costly implications for healthcare providers (1). Overall goals of fluid management should be to maintain euvolaemia while avoiding excess water, salt and electrolyte imbalance. We have looked at factors affecting fluid therapy preoperatively, intraoperatively and postoperatively. Despite generalised concepts behind administration of fluid within ERPs, all patients should have an individualised management plan based upon their own specific needs.

Preoperatively

Patients should present for surgery as euvolaemic as possible and correct any preoperative fluid or electrolyte derangements (1). Avoiding prolonged fasting preoperatively and provision of clear carbohydrate drinks can significantly reduce intraoperative fluid requirements.

Preoperative fasting can lead to increased catabolism, as a result of enhanced muscle degradation for gluconeogenesis, and insulin resistance; a response that can last for days to weeks after surgery (2). Patients who present in a metabolically fed state show reduced postoperative insulin resistance (3). Starvation or nutritional compromise prior to surgery can worsen this response as a result of depleted glycogen storage (4). While extensive research has been done on the use of complex carbohydrate drinks to prevent protein catabolism in exercise, it has only been in recent years that this finding has been extrapolated to prevention of the surgical stress response (5). It is usually recommended that patients are given 45 g of carbohydrates prior to surgery (6). An example regimen is administration of complex CHO maltodextrin 12.5% 800 mL in the evening before and 400 mL 2–3 hours prior to surgery, which has been shown to overcome the catabolic response to fasting and surgery (7). Preoperative carbohydrate drinks can decrease insulin resistance and lower insulin requirements (2,8-10), lowers muscle catabolism (11) and improves haemodynamic stability intraoperatively. Patients with delayed gastric emptying or emergency surgery should ideally remain starved for up to 6 hours preoperatively (6).

Guidelines recommend avoiding the use of mechanical bowel preparation in colonic surgery in order to prevent dehydration and electrolyte derangement as patients can lose up to two litres of fluid as a result of mechanical bowel preparation (6). Iso-osmotic bowel prep has not been shown to have this effect (6).

Postoperative nausea and vomiting (PONV) affects 30–50% of all surgical patients (1) and is also a major cause of patient dissatisfaction. PONV can lead to dehydration, delayed return of GI function, need for nasogastric tube (NGT) insertion, increased IV fluid administration, prolonged hospital stay and increased healthcare cost (1). Particular risk is given to those who are female, non-smokers with a past history of PONV or motion sickness (12). Carbohydrate loading may reduce PONV (3,13) as can prophylactic administration of anti-emetic medications (14) with multimodal therapy and having PONV rescue medication available in a different class of anti-emetic (1).

Intraoperatively

Anaesthetic factors

Anaesthetic agents can cause dose dependent vasodilation and myocardial depression leading to hypotension which is often compensated for with IV fluid administration. Avoiding unnecessarily deep anaesthesia may offset this and recent guidelines have focused on the use of depth of anaesthesia monitoring such as bispectral index (BIS) monitors not just for prevention of awareness but also to avoid the physiological depression associated with anaesthetic maintenance (15). Hypotension due to vasodilation rather than hypovolaemia (provided the patient has not had prolonged starvation and has been adequately hydrated preoperatively) may be better treated with pharmacological vasoconstriction rather than fluid.

Many ERPs encourage the use of intrathecal or thoracic epidural anaesthesia for abdominal surgery. These can result in reduced cardiac output due to vasodilatation and reduced venous return (16). Low dose vasoconstrictors such as phenylephrine may be used to counteract these changes and prevent excessive administration of intravenous fluids.

Surgical factors

Surgical positioning can affect the fluid status of patients. Trendelenburg position is commonly used to improve surgical view, but this can result in increased venous return, right ventricular preload and subsequently stroke volume (17). Over a prolonged time in this position however, haemodynamic changes will return to baseline (17) and will not confer a long-term increased preload.

Laparoscopic surgery is used extensively due to the benefits for patients in terms of recovery and outcomes. Laparoscopic methods can also reduce the surgical stress on the patient, preventing large fluid shifts and therefore decreasing the need for large amounts of intravenous fluid therapy (18), in addition to a decrease in intra operative blood loss and operative time. However, intraoperatively, the increased intra-abdominal pressure caused by insufflation can cause a decrease in venous return, especially at higher pressures. Like surgical positioning, this too can be transient (19). However, an increase in afterload due to insufflation will be sustained which is worth noting, and can disrupt dynamic measurement of fluid responsiveness.

Consequences of intravascular fluid derangement

Hypovolaemia can lead to decreased tissue perfusion and inadequate oxygen delivery to tissues. As little as a 10% decrease in blood volume can lead to a reduction in splanchnic perfusion, acidosis of gut mucosa and potential postoperative complications in the form of ileus and inability to tolerate enteral feed (20). In turn this can lead to a longer hospital stay or delayed discharge (21). Hypovolaemia leading to reduced organ perfusion can increase the risk of more severe postoperative complications such as acute kidney injury, myocardial infarction and cognitive dysfunction which are associated with a higher mortality rate and healthcare cost.

Hypervolaemia should equally be avoided due to risk of tissue oedema which can have consequences for healing and the increased risk of postoperative complications. A significant increase in body weight postoperatively has been associated with increased length of stay, increased morbidity and increased 30-day mortality (22).

Static parameters

Markers such as blood pressure, heart rate, urine output and CVP have traditionally been used to monitor haemodynamic status and assess fluid state. However, these may not be reliable indicators of intravascular fluid status (23). Surgical stress can stimulate the sympathetic nervous system and the renin-angiotensin system. Although this maintains perfusion to vital organs such as brain and heart through systemic vasoconstriction, this may reduce perfusion to kidneys, GI tract and skin despite seemingly normal haemodynamic parameters.

Oliguria alone is not a reliable indicator of fluid status as anti-diuretic hormone release can be a natural response to the physiological stress of surgery (24). Traditional thresholds for oliguria (0.5 mL/kg/h) should not be used intraoperatively as a marker for fluid administration and may lead to volume overload in the euvolaemic patient. However, anuria is not normal and requires urgent attention.

Dynamic parameters

Dynamic parameters have been used in goal directed fluid therapy and are deemed to give superior assessment of fluid ‘responsiveness’ (25). Many recent trials have used arterial waveform variation in mechanically ventilated patients to assess the changes associated with the reduced venous return during inspiration and increased intrathoracic pressure. Normal variation in stroke volume variation is less than 10%; greater than this suggests need for intravascular volume. However, these indices may be less useful during open thoracic procedures, low tidal volumes (<8 mL/kg) or high positive end expiratory pressure (PEEP), patients with arrhythmias and those on vasoactive infusions (26).

Stroke volume can also be used to guide fluid therapy. Commonly used measures of stroke volume are via the oesophageal doppler, lithium dilution technique or arterial waveform analysis. A bolus of 200–250 mL of intravenous fluid is administered and stroke volume increase of over 10% is said to indicate responsiveness to fluid. These measures may be utilised when waveform variation analysis may be inaccurate (27).

Pulse contour analysis is a more recent innovation that is now widely used to measure haemodynamics intraoperatively, and when combined with goal directed fluid therapy can lead to a decrease in postoperative complications, mirroring results seen with more invasive measures of cardiac output such as oesophageal doppler (28). However, there are limitations; for instance, patients requiring high dose vasopressors where there is high cardiac output and low systemic vascular resistance.

Monitoring fluid status/goal directed fluid therapy

Monitoring of fluid status guides fluid administration in order to prevent tissue hypoperfusion.

There are currently three usually described methods of fluid administration. The first is the traditional or standard approach, and replaces fluid lost during surgery and so called ‘insensible’ or 3rd space losses. Fluid given in this manner has been shown to result in a postoperative increase in body weight of 3–6 kg (29).

Goal directed fluid therapy is recommended in most clinical situations as it confers little risk and makes use of advanced haemodynamic monitoring (6). Fluid is given to achieve near maximal stroke volume as measured via oesophageal doppler, or to achieve a stroke volume variation of less than 10% using pulse contour analysis in patients on a mechanical ventilator. Both methods aim to improve cardiac output for patients based on their position on the Starling curve. Traditionally, patient fluid responsive was measured using invasive devices such as pulmonary artery catheter flotation devices. In recent years, minimally invasive cardiac output monitoring has been shown to reduce length of stay (6). This avoids fluid overload in ‘non responders’ while optimising fluid and avoiding hypoperfusion in ‘responders’ (30).

An alternative to goal directed fluid therapy as described above is restrictive fluid administration; paying close attention to fluid balance, replacing all measured losses and avoiding fluid overload. This approach is based upon the thought that interstitial oedema due to excessive fluid administration prevent tissue healing and causes increased risk of postoperative cardiac and pulmonary complications (16). The restrictive fluid approach has been shown to have similar outcome benefits in terms of length of stay and postoperative complication rate to goal directed fluid therapy when compared to standard fluid regimes, with no increased risk of adverse outcomes (16). Intravenous fluids are given intraoperatively to maintain intravascular volume, cardiac output and tissue perfusion while avoiding salt and water overload (1). Homeostasis can be maintained with IV fluids at a rate of 1–4 mL/kg/h (6).

Recent consensus statements and publications advocate the use of a zero-balance approach for patients within an ERP who are deemed low risk and undergoing low risk surgery due to this lack of difference in outcomes (31). However, a large randomised control trial (RELIEF) published in 2018 showed no difference in long term survival between liberal and restrictive fluid regimes, with an increased risk of acute kidney disease in the restrictive group (32). For patients who have higher preoperative risk assessment or who are undergoing major surgery, a goal directed fluid therapy approach is recommended as the benefits become more meaningful in this population (33).

Fluids: crystalloid vs. colloid

The composition of administered fluid can determine its distribution within the body. Crystalloid solutions usually remain within the extracellular space as sodium cannot freely traverse the cell membrane (34). Glucose containing solutions such as 5% dextrose will be metabolised by the liver and the remaining water distributed evenly throughout intra and extra cellular spaces. For this reason, isotonic crystalloid solutions are preferred. Although fluid expansion is better maintained with 0.9% saline when compared to Hartmann's solution (35), 0.9% saline should be avoided due to the risk of hyperchloraemia (33). Hyperchloraemia can cause metabolic acidosis which places the patient under undue physiological stress; this is also associated with postoperative kidney dysfunction and increased length of stay and 30-day mortality (36).

Colloid solutions are human plasma derivatives or semi-synthetic variations. They usually contain plant or animal sourced macromolecules that are suspended in an electrolyte solution. These larger molecules cannot cross the endothelium and therefore they have traditionally been used to improve intravascular volume and have been the basis of many goal-directed fluid therapy trials. However, a recent meta-analysis conducted by Qureshi *et al.* in 2016 found an increased risk of acute kidney injury and need for renal replacement therapy with colloid use when compared to crystalloids in critically unwell septic patients, and no increased benefit of colloid when compared to isotonic crystalloid solutions (37). Colloids also carry an increased risk of anaphylaxis and a dose dependent effect on coagulation (38).

Postoperative period

Where possible, patients should stop receiving IV fluid and recommence unrestricted oral intake as soon as possible (33). This may require awareness, and active treatment of PONV. Provided thirst mechanisms remain intact, patients can regulate their own fluid balance and maintain intravascular volume. An avoidance of intravenous therapy when a patient is able to take oral fluids has been associated with shorter length of stay in colorectal patients (39).

If oral fluid intake is not possible, assuming there are no ongoing surgical losses, the same fluid management principles that were used intraoperatively should continue. Occasionally, this may not be possible due to lack or removal of monitoring devices used intraoperatively.

Summary

Perioperative management of fluids in ERPs should be considered pre-, intra- and postoperatively.

Preoperative carbohydrate drinks can be useful in preventing dehydration and catabolism associated with the surgical stress response. Where bowel preparation is required, iso-osmotic solutions should be used.

In those patients who are deemed to be hypovolaemic, dynamic monitoring of fluid responsiveness can be beneficial in guiding fluid therapy in a goal directed fashion. Low risk patients and low risk minimally invasive procedures should undergo a zero-balance regime to avoid the risks associated with hypervolaemia. When assessing patient fluid status, anaesthetic and surgical factors should be taken into consideration. Most guidelines recommend balanced crystalloid solutions as fluid therapy.

Postoperatively, where possible, patients should commence oral fluid intake as soon as possible and stop IV fluids. If this is not possible, continued haemodynamic monitoring should guide further fluid therapy.

Each patient should have an individualised fluid management strategy according to their specific needs and surgical requirements. The recommendations from this article are summarised in *Table 1* below.

Table 1 Recommendations for fluid management in enhanced recovery programmes

Period	Recommendation
Preoperatively	Minimise fasting time
	Minimise use of bowel prep—use iso-osmotic solutions where possible
	Complex carbohydrate drinks up to 2 hours preoperatively
	Stratify patient risk
Intraoperatively	
Low risk	Standardised monitoring: blood pressure, heart rate, urine output, estimated blood loss
	Aim for 'zero-balance' using balanced crystalloid solutions
High risk	Goal directed therapy (GDT) with dynamic monitoring for fluid responsiveness; stroke volume, cardiac output
	Problem shooting; replace blood loss, correct coagulopathy
Postoperatively	Oral intake as soon as tolerated and disconnect IV fluid
	Continue fluid management as intraoperatively; GDT if appropriate with haemodynamic monitoring

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