PERIOPERATIVE FLUID THERAPY AS A COMPONENT OF ACCELERATED RECOVERY AFTER SURGERY (ERAS) IN CHILDREN

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Abstract. *Adequate fluid therapy in the perioperative period is important to improve postoperative outcomes, since normovolemia is an essential factor in hemodynamic stability and homeostasis. It's clear that the volume and composition of the administered infusion solutions thus affect the duration of the need for artificial lung ventilation (ALV), the duration of stay in the intensive care unit and intensive care. Optimization of perioperative infusion therapy helps to improve postoperative results, reduce perioperative complications and reduce hospital stays. Thus, optimal management of perioperative infusion is an important component of accelerated recovery after surgery (ERAS) pathways.*
Keywords: *perioperative period, ERAS (Enhanced Recovery After Operations), infusion therapy, childhood.*

INTRODUCTION

Current trends in the development of anesthesiology require a change in the tactics of managing patients in the perioperative period due to the introduction of new methods and approaches that reduce the stress response to surgery [1]. Accelerated recovery after surgery (ERAS) is a systematic approach aimed at the rapid comprehensive recovery of the patient's functional state and improvement of clinical outcomes, increased patient satisfaction and reduced financial costs.

Enhanced Recovery After Surgery (ERAS) protocols are now increasingly used in the perioperative setting worldwide. The introduction of ERAS protocols has reduced the length of hospital stay by 30-50%, reduced the risk of complications and significantly reduced the frequency of readmissions [3].

The number of surgical teams studying ERAS in children is growing every year, and there is growing evidence that this approach can improve surgical care for children worldwide. The first ERAS World Pediatric Congress in 2018 laid the foundation for a new era of pediatric surgical safety [4]. In today's world of pediatric surgery, ERAS is successfully used in almost all disciplines, from congenital heart surgery to colorectal surgery. The evolution of ERAS continues to evolve as a quality and safety paradigm.

Without a doubt, the implementation of ERAS requires a culture change based on collaboration rather than traditional disparate approaches to treatment [4].

Optimal hydration management is an important component of the accelerated post-surgery recovery (ERAS) pathways. Optimization of fluid management should begin in the preoperative period and continue at all stages of the perioperative management of surgical patients [5,6].

Objective

To study the role of perioperative fluid therapy tactics in accelerated recovery after surgery (ERAS) protocols in children.

MATERIALS AND METHODS

Search. In the search for publications on perioperative fluid therapy in children in improving the ways of recovery after surgery, the keywords ERAS (Enhanced Recovery After Operations), perioperative period, fluid therapy, children's age were used. A systematic comparative analysis of 167 publications was performed, including the results of original articles, case reports and review publications. Of these, 38 papers that formed the basis of the review turned out to be the most informative. Search queries were conducted in the databases of the Scientific Electronic Library Elibrary.ru, PubMed, Cohrane, Clinicaltrials.gov, Google Scholar, Medline, RSCI and Science Direct from 2005 to August 2023.

RESULTS AND ITS DISCUSSION

A meta-analysis of 38 studies pointed to the advantages of goal-oriented fluid therapy as one of the components of the ERAS protocol, the tactics of which are based on the regulation of cardiac output (CO) and stroke volume (SV) and the achievement of intraoperative fluid balance, especially in high-risk patients [7.8].

When choosing a perioperative infusion regimen, it is also important to be guided by the nature of the surgical intervention and its duration. So according to the results of the study Ts.Tatara, Yo. Nagao, Ch. Tashiro (2009) showed that in patients (n=30) undergoing major surgery lasting more than 5 hours, fluid overload significantly increased interstitial edema, as capillary leakage peaked at 3–4 hours of surgical trauma. And based on this, the authors recommended limiting the fluid regimen during long-term surgical interventions, while with small surgical interventions lasting less than an hour, more benefit can be obtained from higher maintenance doses of fluid [9].

Similar findings are presented in Birgitte Brandstrup et. al. (2006) according to which, limiting the regimen of perioperative intravenous fluid administration reduces the number of complications after elective surgical interventions [10].

Physiology of displacement volume

Adequate fluid and volume therapy before, during, and after anesthesia is important to improve perioperative outcomes, as normovolemia is an essential factor in hemodynamic stability and homeostasis between the intravascular fluid and the extravascular space.

In a review article, Monnet H., Teboul J. (2018) detailed all the circumstances under which a volume bolus would result in increased perfusion and tissue function. The first step is to increase the mean systemic filling pressure, which can be counteracted by capillary leakage and venodilation [6].

Perioperative fluid therapy plays an important role in reducing the risk of surgical infections. Both fluid overload and hypovolemia can impair tissue oxygenation, which adversely affects wound healing as well as the development of surgical infections [5]. Surgical infections lengthen hospital stays, increase the cost of treatment, and become a key indicator of the quality of care. In addition, the systemic inflammatory response associated with tissue damage leads to systemic capillary leak syndrome and tissue edema. One study showed that changing the fluid regimen only on the day of surgery reduced postoperative complications by 50%. [5].

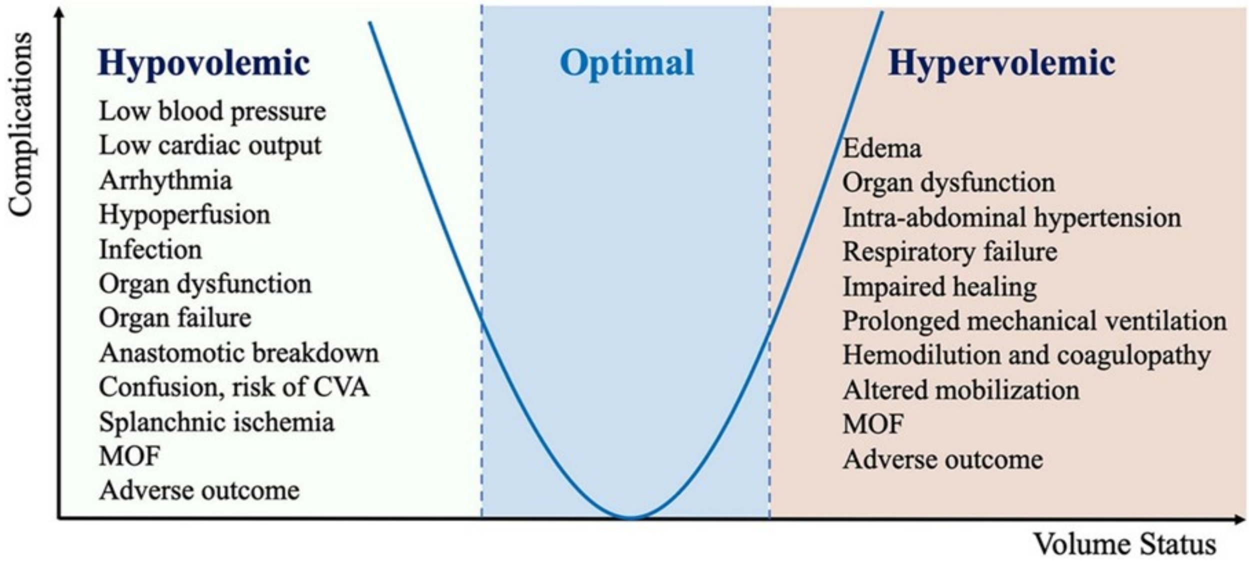


Figure 1 Complication associated with inadequate perioperative fluid management.

Studies performed in recent years have confirmed the effect of infusion therapy on the function of the vascular endothelium, the development and severity of capillary leak syndrome.

Modern aspects of perioperative infusion therapy.

Infusion management is an important and at the same time not a simple component of accelerated recovery after surgery [11]. The volume and composition of the infused fluid directly affect the state of homeostasis and hemostasis, the frequency of postoperative complications, the duration of hospitalization, and the final result of treatment. Therefore, to this day, discussions continue among the luminaries about what fluid should be used and at what rate it should be administered to specific patients.

Thus, fluid therapy, as one of the components of the ERAS program, should be targeted to ensure adequate hydration and maintain euvolemia while avoiding hyper- and hypovolemia.

In the perioperative period, one should distinguish between infusion volume load (bolus) and maintenance (replacement) infusion therapy. The purpose of the volume load (bolus) is to quickly stabilize hemodynamics, microcirculation and oxygen transport with a sharp decrease in preload due to blood loss and/or vasodilation. If necessary, the volume load can be accompanied by continuous maintenance replacement infusion, compensating for natural and pathological losses.

Preoperative period.

The main goal of preoperative fluid therapy is to correct any preoperative fluid and electrolyte disturbances and maintain the euvolemic state as much as possible [12].

Prolonged preoperative fasting may lead to increased catabolism of gluconeogenesis, increased insulin resistance, and potentially reduced intravascular volume. [12,13]. Oral intake of a liquid carbohydrate drink 2 hours before surgery may reduce insulin resistance and insulin requirements, reduce muscle catabolism by minimizing protein breakdown, improve hemodynamic stability during surgery, and possibly promote earlier recovery of bowel function [14,15 ,16].

In 2018, a joint statement from the Association of Pediatric Anesthesiologists of Great Britain and Ireland, the European Society of Pediatric Anesthesiology and L'Association Des Anesthesistes-Renamateurs Paediatriques d'Expression Francaise recognized that, in the absence of contraindications, children should be encouraged to drink clear liquids 1 hour before the scheduled general anesthesia [17]. The liberalized clear liquid fasting policy is based on evidence that water leaves the stomach within 30 minutes, and other clear liquids are nearly eliminated within an hour. There is evidence from randomized control trials demonstrating no significant difference in gastric volume or pH when children are fasted and given clear fluid for 1 hour versus 2 hours [18].

Given that existing ERAS programs adhere to the principle of avoiding prolonged preoperative fasting and preloading with oral carbohydrates, children enter the operating room in an euvolemic state. Which, in turn, avoids the introduction of an excessive amount of infusion. Thus, in the preoperative period, patients should be encouraged to hydrate with carbohydrate-containing clear fluids 2 hours before induction of anesthesia.

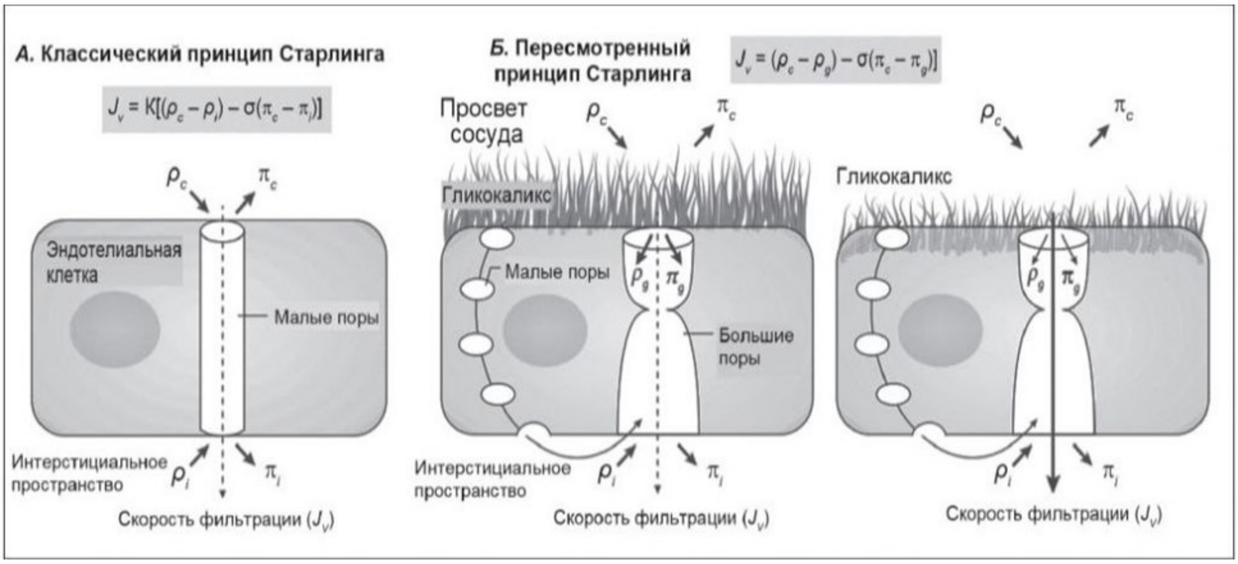
Intraoperative period

The goal of intraoperative fluid therapy is to maintain perfusion of target organs with adequate circulating blood volume. Hypovolemia can lead to an increased risk of organ hypoperfusion, sepsis, and multiple organ failure. Hypervolemia can be equally dangerous, leading to peripheral and pulmonary edema, as well as an increased incidence of postoperative ileus. Thus, maintaining euvolemia should be the goal of intraoperative fluid therapy [6].

For this, patients undergoing ERAS surgery should have an individual management plan for infusion therapy. As part of this plan, excess crystalloids should be avoided. In low-traumatic operations in patients with low operational and anesthetic risk, a "zero balance" approach should be followed. Whereas for patients who have undergone major surgery, individual targeted infusion therapy is recommended, taking into account surgical and individual-age risk factors.

After analyzing a number of works aimed at determining the optimal volumes of perioperative infusion therapy, conflicting data were obtained [18].

Fig.2. The principle of liquid transfer through capillary membranes.



A. Classical Starling model: Jv - fluid flow through capillary membranes; K-factor of filtration; pc – capillary hydrostatic pressure; pi – hydrostatic pressure in the interstitium outside the capillary; ps is capillary osmotic pressure; pi – interstitial osmotic pressure;

B. The revised Starling model is depicted under physiological conditions (intact glycocalyx, left panel) and under pathological conditions (damaged glycocalyx, right panel): ng is oncotic pressure in the subglycocalix space; pg is the hydrostatic pressure of a thin layer of interstitial fluid in the subglycocalix space.

It has been proven that the endothelial glycocalyx also plays a key role in maintaining the integrity of the endothelium. The introduction of an excess amount of fluid leads to hypervolemia and a subsequent increase in intravascular hydrostatic pressure with the release of atrial natriuretic peptides, which disrupt the integrity of the endothelial glycocalyx and provoke platelet aggregation, increasing vascular permeability, resulting in tissue edema [20,21,22]. According to the conclusion of the work of Daniel Chappella and colleagues, intravenous fluid administration without signs of hypovolemia can damage the glycocalyx and transform from the intravascular bed into the interstitial space (commonly called the "third space") [23].

However, in subsequent studies by Matthias Jacob and Daniel Chappell, in which measurements were made using ultrasound techniques, they did not show convincing data on fluid loss and it was decided to abandon the concept of compensating for losses in the “third space” [7,24,25].

The most common manifestation of hypervolemia is edema of the intestinal wall, which complicates the postoperative course of patients who underwent surgery for intestinal obstruction. Even a modest positive fluid and electrolyte balance after elective colon resection has been shown to be associated with delayed recovery of gastrointestinal function, increased morbidity, and increased length of hospital stay. In addition, a study in rats undergoing intestinal resection and anastomosis showed that an excess of crystalloids leads to swelling of the intestinal submucosa, a decrease in anastomotic rupture pressure, and a decrease in the structural stability of intestinal anastomoses in the early postoperative period [26].

The best term to describe low crystalloid regimens is zero-balance fluid therapy, with the goal of maintaining central euvolemia while minimizing excess salt and water [27].

For many patients, minimizing excess fluid using the zero-balance method will be sufficient for their clinical needs (see section on matching patient monitoring needs and surgical risk). However, larger operations with more blood loss and more complex fluid transfers may require fluid boluses to maintain euvolemia. This is often referred to in the literature as volume therapy.

Postoperative period.

Refusal of intravenous therapy, when the patient can take fluids orally, is associated with a shorter length of stay in patients in the hospital [28].

If oral fluid intake is not possible, provided there is no ongoing surgical loss, the same fluid management principles used during surgery should continue, provided monitoring devices are available [29].

A systematic review including 11 studies showed that early feeding reduces the risk of infections of all forms [30].

In consideration of early enteral nutrition results in less bowel edema and faster passage of flatus and stools, as well as a shorter hospital stay, early enteral nutrition is currently recommended. In addition, patients are better able to maintain intravascular volume and maintain fluid balance when they are given fluid control [31].

Infusion therapy in the postoperative period should be carried out only to maintain euvolemia. In order to avoid fluid overload and ensure early mobilization, intravenous fluids are recommended to be discontinued on the 1st postoperative day after switching to oral administration, provided that hourly diuresis is adequate [32].

In a study by Laura N. Purcell, et al. (2021) an increase in the amount of postoperative intravenous fluid (1.0 ml/kg/hour) resulted in an increase in the length of stay in the hospital by 43.5 hours. According to the results of their retrospective cohort study of 139 patients under 18 years of age, a decrease in total postoperative fluid volume was associated with a decrease in length of hospital stay with no difference in complication rates [33].

Intravenous fluid administration can be resumed only if clinically indicated [5].

In the absence of other concerns, harmful postoperative fluid overload is not warranted and "tolerable oliguria" can be tolerated. patients undergoing surgery as part of an extended recovery protocol should have an individual infusion management plan. As part of this plan, excess crystalloids should be avoided in all patients.

Monitoring of perioperative fluid therapy

New technologies can help assess patient response to fluid (esophageal Doppler, non-invasive cardiac output monitoring, pulse wave analysis, plethysmography index, peak aortic blood flow). The goal of these technologies is to provide a metric to classify patients in whom fluid administration will improve cardiac output and optimize tissue perfusion, and in whom preloading therapy is unnecessary and will result in fluid overload. In mechanically ventilated patients, dynamic preload measures, which depend on respiratory changes in stroke volume, are better predictors of infusion response than static variables. Further research is needed in children to determine fluid administration, evaluation, and optimal maintenance of euvolemia [13,32].

Respiratory plethysmographic waveform variations are the most commonly available fluid management parameter, as pulse oximetry is the standard non-invasive intraoperative monitoring method in mechanically ventilated patients [33]. The main problem in the clinical use of the plethysmographic waveform is the significant effect of vasoconstriction (eg, hypotension, hypothermia) on its shape. However, an increase in the plethysmographic wave may be the first sign of the development of still latent hypovolemia and should prompt the idea of immediate fluid administration [34].

Pulse contour analysis is a more recent innovation that is now widely used to measure hemodynamics during surgery and, when combined with targeted fluid therapy, may result in a reduction in postoperative complications, mirroring the results seen with more invasive cardiac output measurements such as esophageal Doppler. [35,36].

In recent years, minimally invasive cardiac output monitoring has been shown to reduce hospital stays [37].

With extensive surgical interventions, laboratory monitoring of the acid-base state (ACS), control of osmolality and electrolyte composition of blood plasma is recommended; hemoglobin concentration in relation to the hemotocrit index. In addition, dynamic monitoring of serum lactate concentration and / or base deficiency is necessary as sensitive tests for assessing the degree of bleeding, the need for blood transfusion, shock of any origin and multiple organ failure during perioperative infusion therapy.

The amount of lactate produced due to anaerobic glycolysis is considered a marker of oxygen deficiency, tissue hypoperfusion, and severity of shock [36]. Similarly, the value of base deficiency in arterial blood gas analysis provides an indirect estimate of total tissue CBS in impaired tissue perfusion [37].

Another technique that is used to monitor fluid therapy in the perioperative period in critically ill patients is transpulmonary thermodilution followed by pulse wave analysis. A number of studies have demonstrated the effectiveness of thermodilution indicators and pulse wave analysis, including global end-diastolic volume, extravascular lung water, pulse pressure and stroke volume variations, for the purpose of perioperative monitoring, hemodynamic optimization and targeted therapy [38].

CONCLUSION

ERAS protocols are associated with improved outcomes. Targeted fluid therapy is a key element of ERAS protocols, which can only be achieved with good monitoring. Management of the infusion system within the ERAS protocols should be considered as a continuous process in the preoperative, intraoperative and postoperative periods. Fluid therapy is the cornerstone of perioperative medicine, but being clear about when not to inject fluids is just as important as when to inject.

The goals of the ERAS pathways are to reduce postoperative complications and facilitate earlier recovery after major surgery. Optimal perioperative management of the infusion system, an important component of this approach, is often underestimated.

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