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EDITORIAL VIEW

Perioperative crystalloids in pediatric surgical patients: current approach

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ABSTRACT

Anesthetists are traditionally responsible for managing intraoperative fluid balance. For nearly half a century the traditional intraoperative fluid management in pediatric patients has been based on the formula by Holliday and Segar and was limited to glucose containing hypotonic fluids. There is now evidence that this results in morbidity and mortality related to a high risk of developing hyponatremia in the postoperative period. Expert opinion now favors isotonic fluids with low glucose concentration.

This editorial highlights the need for change in practice regarding both composition and volume of perioperative crystalloid fluids in children undergoing surgery, and the current recommendations on fasting, third space and postoperative fluid losses.

Keywords: Fluid therapy; Fluid balance; Pediatric; Perioperative period; Crystalloid solutions

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Traditionally intraoperative fluid management has been the domain of anesthesiologists. Anesthesia practice has changed over the years, the nil per orum guidelines now recommend a much shorter period of fasting.[1] It has also been argued that the current formulas used for calculating fluid deficit overestimate the volume needed for maintenance, thus resulting in hyponatremia.[2] Hyponatremia may lead to cerebral swelling, decreased consciousness, seizures, coma or even sudden death.[3]

In the recent years both the volume of fluid given in the perioperative period as well as the type of maintenance fluid has been questioned by anesthesiologist as well as pediatrician.[4,5]

Physiological Basis

Fluid requirement in pediatric practice is based on the ongoing losses of water and electrolytes. Water requirements relate to both insensible losses from skin (30ml/100 kcal), from respiration (15mL/100kcal) and insensible loss in urine and faeces. These losses can vary with physiological as well as pathological conditions. Electrolyte are mainly lost in the urine and the daily needs are calculated as sodium and chloride 2-3 mEq/100 ml of water/day and K+ as 1-2 mEq/100 ml of water/day.[6]

Water requirements depend on energy expenditure, approximately 100 ml of H_2O is required for every 100 Kcal/kg of energy expended but it also varies with fasting, prematurity, fever, presence of ileostomy or colostomy, positive pressure ventilation, etc. where fluids will need adjustments. Similarly Na+ and K+ intake will need alteration in conditions like diarrhea and burns.

Composition of Preoperative Fluid for Background Infusion

There is now evidence that hypotonic maintenance fluids with 5% dextrose are associated with hyponatremia which may lead to cerebral oedema,

encephalopathy and respiratory insufficiency.[7,8]

The two balanced isotonic salt solution recommended and now commonly used are Ringers lactate (RL) and normal saline (NS). In comparison to extracellular fluid RL is slightly hypotonic and can theoretically reduce osmolarity. It is relatively contraindicated in patients at risk with cerebral edema for example in head injury, CNS infections etc. and those with chloride deficiency, for example in vomiting.9 Sodium chloride on the other hand contains 154 mmol/L of chloride in contrast to 95 – 106 mmol/L in plasma. Infusion of small amounts does not have undesirable effects but larger volumes of NS may lead to hyperchloremic metabolic acidosis. Larger volume can also impair renal function, vascular permeability, acid base balance, and coagulation.[9]

In 2011 a European consensus statement recommended that intraoperative fluids for background infusion should have osmolarity and Na+ content as near to physiological range as possible and contain 1-2.5% glucose as well as metabolic anions.[10] Such balanced electrolyte solutions with 1-2.5% dextrose are available in some European countries and are used especially in younger children. Use of such a solution prevents both hypo and hyperglycemia and prevents lipolysis.[11]

There is now general agreement that routine dextrose containing fluids are not recommended for healthy children[12,13] including neonates unless in a subgroup which is at a greater risk of hypoglacemia. These are premature neonates, those on hyper alimentation and with endocrinopathies.[14] Mierzewska-Schmidt et al compared three fluid regimes (5% dextrose water, 3.33% glucose in 0.3% NaCl and Ringers acetate) in 91, ASA 1 and 2 children undergoing ENT surgery. Postoperative hyperglycemia was seen in 94% and hyponatremia in 36% of children, who received 5% dextrose water. No hyperglycemia or hyponatremia was seen in children who received RL.[15]

Volume of Preoperative Fluid for Background Infusion

Maintenance fluid requirement during surgery have traditionally been calculated on the formula recommended by Holliday and Segar which has been used for more than half a century. This formula recommends an hourly maintenance requirement of 4 ml/kg of fluid per kg for the first 10 kg of the child's weight, 2 ml/kg for the next 10kg and 1 ml/kg for subsequent kilograms. The fluid recommended was 0.18% saline in dextrose 4% solution,[16] this solution is hypotonic but meets the predicted maintenance requirements of water and sodium. Dextrose makes the solution iso-osmolar. This solution was originally meant for hospitalized nonsurgical children.

This proposed fluid requirements by Holliday and Segar was translated into hourly fluid requirements and is known as "4-2-1 rule" that is 4 ml/kg/h. for children 3 – 10 kg weight, 40 ml/h + 2 ml/kg/h for each kg from 11 – 20 kg weight, and 60 ml/h + 1 ml/kg/h for each kg above 20 kg.[17]

Recent German guidelines for perioperative fluid administration in children recommends a "Rule of 10" that is background infusion rate of 10 ml/kg/h of a balanced salt solution. In case of circulatory instability 10 – 20 ml/kg/h, the recommendation is to repeat infusion till cardiovascular stability is achieved.[11]

Replacement of Fasting and Third Space Losses

Furman et al. recommended calculating the preoperative fluid deficit by multiplying the fasting period in hours with the hourly rate calculated based the "4,2,1 formula",[18] replacing 50% of the volume in first intraoperative hour and 25% each in the subsequent hours. With the new fasting guidelines1 the replacement of fasting deficit is no longer important. There is now evidence that healthy patients maintain normal volumes and blood sugar in spite of prolonged fasting.[19]

Traditionally isotonic fluids have been recommended to replace the third space losses from extracellular space to a nonfunctional third space. Depending on nature of surgery 1 ml/kg/h to 15 ml/kg/h has been recommended.[17] A review of adult literature concluded that a classic third space does not exist20 but the research on this topic in pediatric literature is deficient[17]

Postoperative Fluid Requirements

Postoperatively free water elimination is impaired due to increased ADH secretion and can result in hyponatremia (Na < 135 mmol/l) if hypotonic solution are administered intraoperatively or in early postoperative period. This can result in a shift of water from extracellular to intracellular space and can cause cerebral edema. If the child cannot start oral feeding early i.e. within the first three hours an IV line needs to be maintained. Ongoing losses due to nasogastric suction, peritoneal drains and ongoing blood loss need to be taken into account. Replacement of ongoing losses should be with isotonic fluids or colloids / blood if indicated. The Association of Paediatric Anesthetist guidelines from UK do not

recommend an ideal fluid or a specific maintenance rate in the postoperative period. Some recommend the full rate based on Holliday & Segar's formula, others restrict it to 60 – 70% of full maintenance.[13]

Recent Guidelines

Consensus based guidelines released in 2017 by Association of the Scientific Medical Societies in Germany recommend a balanced isotonic electrolyte solution (BS) with 1-2.5% glucose as a background infusion.[11]

Chinese guidelines published in 2015 also recommend a balanced salt solution with 1-1.2% glucose as initial infusion except in certain populations.[21]

Nice guidelines 2015 on intravenous fluid therapy in children and young people in hospital are also available. These guidelines do not specifically address the surgical population but the general principles of fluid therapy in the pediatric age group. They recommend use of glucose free crystalloids that contain Na+ in the range of 131-154 mmol/L for fluid resuscitation and isotonic crystalloids with or without glucose for routine maintenance but do not specify which isotonic fluid.[22]

CONCLUSION

Current recommendation is to use balance isotonic salt solution for fasting losses as well as intraoperative background infusion and third space losses. RL and NS are the two solutions most commonly used. In 2011 a European consensus statement recommended that intraoperative isotonic salt solution should also contain 1 – 2.5% dextrose. A higher concentration of dextrose solution is not recommended for healthy children including full term neonates.

Conflict of interest: None declared by the author

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We warmly welcome our new members of the Review Board.

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