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BMH Medical Journal 2016;3(3):72-75 **Brief Review**

Current Thinking In Pediatric Peri-operative Fluid Therapy

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Abstract

Proper perioperative fluid management is critical to maintain cardiovascular stability and adequate tissue perfusion. The volume and composition of fluid should be adapting to the physiology of the child and compensating for the peri-operative events. Traditionally physicians were calculating pediatric maintenance fluid requirements based on studies conducted on healthy children more than 50 years ago by Holliday and Segar. But a search of literature failed to reveal a relevant prospective study critically evaluating the content and volume of Holliday and Segar prescription. But off late there has been a major debate and re-evaluation about this concept because of serious concerns regarding development of hyponatremia and hyperglycemia. This can result in serious neurological damage or even death in a sick child. This brief review is an attempt to explain how the original concept was formed and what is the current thinking?

Key Words: Peri-operative Fluid Therapy, Pediatric

Original concept

Credit for introducing a systemic approach in calculating both volume and composition of peri-operative intravenous fluids goes to Holliday and Segar. In 1957 they have introduced practical methods for prescribing parenteral fluids based on the metabolic needs of a child at rest [1]. The caloric requirement for infants weighing up to 10 kg was 100 kcals/kg, for children of 10-20 kg, 1000 kcals+50 kcals/kg for each kg over 10kg and in above 20 kg category, 1500 kcals+20 kcals for each kg over 20 kg [1]. To establish water requirements, Holliday and co-workers have taken into consideration the physiological fluids needed for energy expenditure [3]. For that it was assumed that under normal circumstances, 1ml of water is required to metabolize 1 kcal. This includes presumed insensible losses across skin, respiratory tract and urinary water. So by correlating the energy requirement with the corresponding water consumption, Holliday and Segar introduced 4/2/1 rule for the hourly fluid infusion in the peri-operative period[1]. In the same study, Holliday and Segar introduced the concept regarding maintenance electrolyte composition of peri-operative fluids [1]. The idea for which was derived from the electrolyte contents in the same volume of human milk. Based on this, it was recommended that an intake of 2 meq/100kcals/day of both potassium and chloride and 3meq/100kcals/day of sodium. So this maintenance fluid and electrolyte solution resulted in infusion of hypotonic electrolyte solution. For many decades the fluids prescribed by the physicians was one-fourth to one-third strength saline based on this concept [4].

However with reports of critical hyponatraemia or hypoglycemia emerging, these hypotonic solutions are now considered suboptimal for pediatric peri-operative use [5,6].

Iatrogenic hyponatremia

It is now clear that the main deterrents for iatrogenic hyponatraemia are 1) Stress induced secretion of anti diuretic hormones (ADH). 2) Administration of hypotonic solutions peri-operatively [7,8]. ADH secretion can result in impaired ability to excrete free water by increasing resorption in the distal renal tubules and collecting duct [7,8]. There are many commercially available glucose containing isotonic solutions which have technically limited sodium content. But these solutions will be soon converted to be hypotonic as soon as glucose is transported intracellular and metabolized [8]. In order to safe guard against overhydration and hyponatremia many authors have suggested to restrict administration of postoperative fluids by 33-50% in view of stress induced ADH response [9,10]. If not child can easily go for over hydration and hyponatraemia. In a recent editorial, Karen Choong et al attributed iatrogenic hyponatraemia to maintenance solution tonicity rather than to volume [11]. Hyponatraemia if not detected and corrected can result in cerebral oedema, brain stem herniation or even death. In comparison to adults, children are more prone to acute encephalopathy probably because of their bigger brain size with respect to skull size [12].

Should we give glucose supplementation?

In pediatric patients, hypoglycemia can cause devastating effects especially in the setting of hypoxia with serious neural injuries [13]. There is also practical considerations of detecting hypoglycemia in an anesthetized child. So routine administration of dextrose was considered as a standard practice once. On the other hand, risk of perioperative hyperglycemia was underestimated at that time. Intraoperative administration of 5% dextrose for prevention of hypoglycemia will result in hyperglycemia due to stress induced insulin resistance [14]. Hyperglycemia can also result in osmotic diuresis, electrolyte disturbances, dehydration, impaired cell function and even cell death [3]. So taking into consideration these contradictory views, there was a complete re-evaluation on this concept.

Presently the well accepted compromise between avoiding hypoglycemia and hyperglycemia is to use isotonic fluids with lower glucose concentration (1-2.5%) [15]. There are also certain situations wherein glucose supplementation is recommended. These are children with high risk of developing hypoglycemia as in preterm neonates, children receiving hyperalimentation, patients with mitochondrial diseases and those with endocrinopathies [16]. Other than these special circumstances, routine dextrose administration is now no longer advised for healthy children receiving anaesthesia even in neonatal period [17].

Do we need to correct fasting deficit?

It was presumed that as a result of fasting, child may develop pre-operative fluid deficits secondary to continuing insensible losses and urine output. So to correct this deficit, a fluid formula was put forwarded by Furman et al [18]. It was proposed to calculate the fluid needs by multiplying the hourly fluid requirement rate, as dictated by the Holliday and Segar method with the hours of fasting [18]. This was further simplified by Berry et al by 25ml/kg for children 3 years and younger and 15 ml/kg for children 4 years and older [19]. The basic assumption in both these fluid guidelines is that children were fasting for at least 6-8 hours. But with new fasting guidelines by American society of Anaesthesiologists (ASA), which allow children to have clear fluids up to 2 hours before surgery, dehydration secondary to nil per oral (NPO) status has become less relevant [20]. But despite these, occasionally children may still present for surgery with prolonged fast. This can result in significant volume deficits especially in sick children. Correcting fluid status in such situations should be based on clinical and laboratory evidence of dehydration and electrolyte imbalances. But most paediatric anaesthesiologists will agree that even after 4-6 hours of fast, older infants and children usually do

not have any evidence of volume compromise.

Summary

An appropriate solution for pediatric intraoperative use should have sodium content close to physiological range. For half a century content and volume was based on Holliday and Segar recommendation. But use of hypotonic solution with 5% dextrose added is found to result in serious hyponatremia, hypoglycemia or even death in a sick child. Because of these concerns, current thinking favors use of isotonic solutions with a glucose requirement of 1-2.5%. For a healthy child following ASA guidelines of fasting dehydration becomes an unlikely event.

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