

Original Research Article

The Effect of Isotonic and Hypotonic Fluid on Serum Sodium in the Pediatric Patient during Surgery

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Journal homepage:<https://www.easpublisher.com>**Quick Response Code****Abstract: Introduction:** Patients need intravenous fluids during Surgery to maintain adequate intravascular volume, cardiac output, and ultimately tissue Oxygen delivery.**Aim of the study:** Aim of the study was to evaluate serum sodium after infusion of isotonic fluid containing 131 mEq/L sodium with no glucose versus that after infusion of hypotonic fluids containing 75 mEq/L sodium with 5% dextrose. **Methods:** This study was conducted on pediatric patients of Bangladesh Shishu Hospital and Institute who underwent hernia operations between January 2021 and September 2021. Data are given as mean±standard deviation. P-value <0.05 was considered to be significant. continuous demographic variables were compared using the unpaired t-test, and the chi-square test was used for categorical variables. **Result:** There were no adverse events and all 40 patients enrolled in this study completed the procedures. The pre-anesthesia and post-anesthesia induction blood sodium concentration. Pre-anesthesia sodium (mEq/L), Isotonic was 138.7 ± 1.4 and Hypotonic was 138.9 ± 1.5 , the charges from pre-anesthesia to postanesthesia induction was -0.20 ± 1.6 . Post-anesthesia sodium (mEq/L), Isotonic was 138.5 ± 1.5 and Hypotonic was 137.3 ± 1.2 , the charges from pre-anesthesia to postanesthesia induction was -1.60 ± 1.8 . **Conclusion:** The administration of hypotonic fluids tends to reduce serum sodium absorption in pediatric cases, indeed when administered for a short period. But the use of isotonic fluids helps to avoid a reduction in serum sodium in pediatric and so may enhance patient safety.**Keywords:** Isotonic and Hypotonic Fluid, Serum Sodium, Pediatric Patient, Surgery.

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INTRODUCTION

Fluid therapy in children may be associated with iatrogenic hyponatremia [1]. Dextrose is metabolized in blood, so although 5% dextrose solution is isomolar to plasma, and isotonic in vitro, once given, the dextrose is metabolized and it effectively becomes water. Dextrose solutions, unless they contain electrolytes of an equivalent amount to plasma are therefore termed hypotonic fluids [2, 3]. Children given hypotonic fluid may become hyponatremic. The brain is particularly vulnerable to acute hyponatremia; this can manifest as cerebral edema, raised intracranial pressure, and can cause brain stem herniation, coning, and death [4, 5]. Prepubertal children are particularly susceptible to brain damage associated with postoperative hyponatremic encephalopathy. In healthy children, an isotonic solution containing no glucose has been recommended as an intraoperative maintenance fluid due to the risk of hyponatremia associated with hypotonic solutions [6, 8]. As isotonic fluid contains the

same concentration of solutes as plasma and therefore exert an equal osmotic force. It's our practice, to only use solutions in the intraoperative period that are isotonic with plasma, compound sodium lactate (Hartmann's solution) being our standard intraoperative maintenance fluid. Our study aimed to evaluate serum sodium after infusion of isotonic fluid containing 131 mEq/L sodium with no glucose versus that after infusion of hypotonic fluids containing 75 mEq/L sodium with 5% dextrose.

METHODOLOGY & MATERIALS

This study was conducted on pediatric patients of Bangladesh Shishu Hospital and Institute who underwent hernia operations between January 2021 and September 2021. Inclusion criteria were age between 2 and 8 years, American Society of Anesthesiologists physical status I, and only one-sided inguinal hernia. Patients with any other comorbidities and preoperative laboratory abnormalities were excluded. We chose one-

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sided inguinal hernia as the study operation because the procedure is highly standardized, meaning that operation times, intraoperative blood loss, and the dose of anesthetic agents and infused fluid were relatively constant with minimal variability among patients. We compared the change in plasma sodium before and following surgery. Random numbers randomly divided the patients to either hypo or an iso in a 1:1 ratio. The patients were blinded. The blinding and allocations were done by another anesthesiologist who did not participate in the trial. Before entering the operating room, blood samples were obtained for the determination of sodium concentration. This was defined as pre-operative value. Informed consent for surgery and participation in this study under general anesthesia was obtained from each patient's parent. According to recommendations, children were allowed milk for up to 4 hours and clear fluid for up to 2 hours

before surgery. After entering the operating room, inhalational induction was commenced with the administration of oxygen and sevoflurane. An intravenous line for administration of the fluid was secured and selected fluid was given. As blood loss is negligible, intraoperative fluid is given as 4 ml/kg/hr for body weight up to 10kg, 2 ml/kg/hr for 11 to 20 kg body weight, 1 ml/kg/hr for body weight over 20 kg. For the first hour of surgery, the supplement dose is the total maintenance dose of the first half of the fasting period, for the rest of the surgery; the supplement dose is one-quarter of the entire fasting period. Patients were intubated 1microgram/kg fentanyl and 0.8 mg/kg vecuronium. Anesthesia was maintained with sevoflurane. Again we collected the blood sample for sodium concentration determination. This is a post-anesthetic sodium value.

Table-1: Composition of Study Fluids

Fluids	Isotonic Solution	Hypotonic Solution
Sodium, mEq/L	131 mEq/L	75 mEq/L
Chloride, mEq/L	111 mEq/L	75 mEq/L
Glucose, g/L	0	50 g/L
Potassium, mEq/L	5 mEq/L	0
Calcium, mEq/L	2 mEq/L	0

STATISTICAL ANALYSIS

Data are given as mean+standard deviation. P-value <0.05 was considered to be significant. continuous demographic variables were compared using the unpaired t-test, and the chi-square test was used for categorical variables.

RESULTS

Forty patients were finally enrolled and analyzed in this study. Patients' demographic

characteristics are shown in table-2. There were no adverse events and all 40 patients enrolled in this study completed the procedures. Table-3 shows the pre-anesthesia and post-anesthesia induction blood sodium concentration. Pre-anesthesia sodium (mEq/L), Isotonic was 138.7 + 1.4 and Hypotonic was 138.9 + 1.5, the charges from pre-anesthesia to postanesthesia induction was - 0.20 + 1.6. Post-anesthesia sodium (mEq/L), Isotonic was 138.5 + 1.5 and Hypotonic was 137.3 + 1.2, the charges from pre-anesthesia to postanesthesia induction was - 1.60 + 1.8.

Table-2: Patient demographics

Variables	Isotonic	Hypotonic	P-value
Age (years)	5+2	5 + 3	0.132
Height (c. m)	110.8+5.4	111.7 + 6.9	0.178
Weight (kg)	154 + 5.4	15.9 + 5.8	0.297
Sex (Male/Female)	14/6	12/8	0.576
Total Anesthesia time (min)	60+12	56 + 16	0.84
Infused fluid per body weight ml/kg	6.1 + 2.3	6.3 + 1.9	0.103

Table-3: Pre-anaesthesia and post-anesthesia induction blood sodium concentration

Pre-anesthesia	Post-anesthesia	The charges from pre-anesthesia to postanesthesia induction
sodium (mEq/L)	Sodium (mEq/L)	Sodium (mEq/L)
Isotonic 138.7 + 1.4	138.5 + 1.5	- 0.20 + 1.6
Hypotonic 138.9 + 1.5	137.3 + 1.2	- 1.60 + 1.8
P-Value 0.624 (NS)	0.0006	0.0082

DISCUSSION

Acute hyponatremia should be avoided in children. Children given hypotonic fluid may become

hyponatremic [7, 8]. If the plasma sodium falls rapidly to a low level, water moves into the cells in compensation and causes swelling of the cells. The brain is vulnerable to acute hyponatremia, this can

manifest as cerebral edema, raised intracranial pressure, which can lead to headaches, nausea, vomiting, confusion, and even death [9, 10]. A retrospective study of patients with acute hyponatremia has shown that more than 50% of children develop symptoms when the plasma sodium is less than 128 mmol/L and that there is a mortality of 8.2% for severe acute hyponatremia [11, 12]. In recent years, many studies and case reports have shown that hypotonic fluid containing 30.4-75 mEq/L sodium with 5% dextrose may occasionally result in permanent neurologic damage or death [13]. During the intraoperative period, some conditions like endotracheal intubation, the procedure of surgery, increases stress-induced secretion of antidiuretic hormone, which causes hyponatremia [13, 14]. In pediatric patients, even a small decrease in sodium concentration can lead to cerebral herniation due to an increased brain-to-skull size ratio and smaller intracerebral volume of cerebrospinal fluid. This study showed that hypotonic fluid reduces serum sodium, even when administered for the short period required for anesthesia induction. Antidiuretic hormone secretion increases under certain conditions, such as tracheal intubation, resulting decrease in serum sodium concentrations [15]. In a previous study, patients with raised vasopressin levels, who received hypotonic fluids, had significant falls in serum sodium levels [16]. In other studies, over-infusion causes a decrease in serum sodium following fluid infusion [17]. In this study, the volume of fluid was given as required, based on the 4-2-1 rule. Thus, patients in both groups had received approximately 6.1 ml/kg of intravenous fluid by the time of blood collection for measurement of post-anesthesia induction value. In contrast, sodium level did not change in the isotonic group in this study, demonstrating that administration of isotonic fluid containing 131 mEq/L sodium enables maintenance of post-anesthesia induction sodium concentrations, due to their similarity to normal blood sodium concentration.

Limitations of the study

CONCLUSION AND RECOMMENDATIONS

Conclusion: In this study, the difference between pre and post-anesthesia induction sodium concentration in the hypotonic group was statistically significant. In contrast, isotonic fluid tends to overcome the decrease of serum sodium concentration in the pediatric patient group.

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Ethical approval: The study was approved by the Institutional Ethics Committee.

REFERENCE

1. McNab, S. (2015). Isotonic vs hypotonic intravenous fluids for hospitalized children. *Jama*, 314(7), 720-721.
2. National Patient Safety Agency. Reducing the risk of hyponatremia when administering intravenous infusions to children. [Cited July 21, 2017]. Available from: <http://www.nrls.npsa.nhs.uk/resources/?EntryId45=59809>
3. Holliday, M. A., & Segar, W. E. (1957). The maintenance need for water in parenteral fluid therapy. *Pediatrics*, 19(5), 823-832.
4. Boehm, G., Stahl, B., Jelinek, J., Knol, J., Miniello, V., & Moro, G. E. (2005). Prebiotic carbohydrates in human milk and formulas. *Acta Paediatrica*, 94, 18-21.
5. Von Baeyer, C. L., Spagrud, L. J., McCormick, J. C., Choo, E., Neville, K., & Connelly, M. A. (2009). Three new datasets supporting use of the Numerical Rating Scale (NRS-11) for children's self-reports of pain intensity. *PAIN@*, 143(3), 223-227.
6. Von Baeyer, C. L., Spagrud, L. J., McCormick, J. C., Choo, E., Neville, K., & Connelly, M. A. (2009). Three new datasets supporting use of the Numerical Rating Scale (NRS-11) for children's self-reports of pain intensity. *PAIN@*, 143(3), 223-227.
7. Arief, A. I., Ayus, J. C., & Fraser, C. L. (1992). Hyponatraemia and death or permanent brain damage in healthy children. *British Medical Journal*, 304(6836), 1218-1222.
8. Armon, K., Riordan, A., Playfor, S., Millman, G., & Khader, A. (2008). Hyponatraemia and hypokalaemia during intravenous fluid administration. *Archives of disease in childhood*, 93(4), 285-287.
9. Wattad, A., Chiang, M. L., & Hill, L. L. (1992). Hyponatremia in hospitalized children. *Clinical pediatrics*, 31(3), 153-157.
10. Crellin, D. J., Harrison, D., Santamaria, N., & Bahl, F. E. (2015). Systematic review of the Face, Legs, Activity, Cry and Consolability scale for assessing pain in infants and children: is it reliable, valid, and feasible for use?. *Pain*, 156(11), 2132-2151.
11. Mikawa, K., Maekawa, N., Goto, R., Tanaka, O., Yaku, H., & Obara, H. (1991). Effects of exogenous intravenous glucose on plasma glucose and lipid homeostasis in anesthetized children. *Anesthesiology*, 74(6), 1017-1022.
12. Stocker, C. F., & Shekerdemian, L. S. (2006). Recent developments in the perioperative management of the paediatric cardiac patient. *Current Opinion in Anesthesiology*, 19(4), 375-381.
13. Park, J. T. (2017). Postoperative acute kidney injury. *Korean journal of anesthesiology*, 70(3), 258.

14. Way, C., Dhamrait, R., Wade, A., & Walker, I. (2006). Perioperative fluid therapy in children: a survey of current prescribing practice. *BJA: British Journal of Anaesthesia*, 97(3), 371-379.
15. Moritz, M. L., & Ayus, J. C. (2005). Preventing neurological complications from dysnatremias in children. *Pediatric Nephrology*, 20(12), 1687-1700.
16. Holliday, M. A., & Segar, W. E. (1957). The maintenance need for water in parenteral fluid therapy. *Pediatrics*, 19(5), 823-832.
17. Rajesh, M. C. (2016). Current thinking in pediatric peri-operative fluid therapy. *BMH Medical Journal-ISSN 2348-392X*, 3(3), 72-75.

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