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Effect of Intravenous Fluid on Perioperative Plasma Sodium Concentration in Pediatric Surgical Patients

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Abstract

Background: The aim of this study was to determine the suitable maintenance fluid that sustains normal plasma sodium levels in children that are 5 years and below in the perioperative period by comparing 4.3% dextrose in 0.18% saline with Ringer’s lactate when either is administered as maintenance fluid.

Materials and Methods: This comparative prospective study was carried out at the pediatric surgery unit of the Obafemi Awolowo University Teaching Hospital, Ile Ife, Nigeria between September 2014 and October 2015. 50 patients were enrolled, 25 in each group. One group received 4.3% dextrose in 0.18% saline, while the other group received Ringer’s lactate as maintenance fluid in the perioperative period. Serial blood and urine samples were collected before, during and after the surgery up till the first 24 hours after surgery. These samples were analyzed for concentration of sodium and creatinine. Fractional excretion of sodium was calculated. Data were analyzed using SPSS software (version 22.0).

Results: The mean age of the study population was 30.6±19.33 months. The mean age of the patients on dextrose saline and Ringer’s lactate was 28.72±20.3 32.52±18.53 months, respectively (p=0.49). The proportion of patients that developed hyponatraemia in the group that received hypotonic fluid was 32% (8/25), while it was 8% (2/25) in the group that received isotonic fluid (p=0.034). The patients who received Ringer’s lactate as maintenance fluid also had a higher mean plasma sodium concentration during the study.

Conclusion: Ringer’s lactate was found to be a better fluid in terms of preventing hyponatraemia in children who are five years and below during the perioperative period compared to 4.3% dextrose in 0.18% normal saline.

Key Words: Hypotonic fluid, Isotonic fluid, Hyponatraemia, Pediatric patient, Perioperative.

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1- INTRODUCTION

Fluid management of the pediatric surgery patient is one of the essential components of care of the pediatric surgical patient. Infants and children are sensitive to fluid and electrolytes derangement and the commonly used fluid protocols for pediatric fluid therapy do not consider rapidity of ongoing changes in perioperative physiology (1). Fluid and electrolyte therapy is an important and critical aspect of the care of the hospitalized child. A thorough understanding of the changing requirements of growing children is fundamental in appreciating the various physiologic changes that occur from birth to adulthood (2). Complex surgical procedures are often associated with rapid changes in fluid requirements that necessitate frequent assessment and sometimes modifications of ongoing fluid therapy. In the operating room, the fluid and electrolyte requirements may rapidly change during the conduct of anaesthesia and surgery; this may be associated with changes in temperature, metabolism and body fluid shifts.

Trauma, haemorrhage and tissue exposure that comes with surgery often shifts body fluids between compartments. This necessitates fluid replacement with intravenous solutions that compensate for energy, protein, water and electrolyte losses. Perioperative fluid therapy comprises of both the volume and composition adjustment to meet the patient status, the type of operation (major or minor) and the expected events in the postoperative period. Fluid therapy is aimed at correcting fluid deficit and providing the volume of fluid needed to maintain adequate tissue perfusion (3, 4). Maintenance fluid therapy in children has been based for over fifty years on Holliday and Segar’s recommendation (5). They recommended that for weights ranging from 0 to 10 kg, the fluid requirement is 100ml/kg/day; from 10 to 20 kg the fluid requirement is 1000ml plus 50ml/kg for each kilogram of body weight more than 10; over 20 kg the requirement is 1500ml plus 20ml/kg for each kilogram more than 20kg. It puts the average maintenance for sodium, chloride and potassium at 3, 2 and 2 mmol/kg/day respectively. Most literatures agree with the Holliday and Segar’s recommendation based on the daily fluid requirements but appear to differ on what should be the electrolyte composition of the fluid (6). Some authors believe in the use of hypotonic saline as it provide the maintenance requirement for sodium, other authors believe hypotonic saline causes iatrogenic hyponatraemia hence the need for isotonic fluid as maintenance fluid in pediatric patients[6].There seem not to be a consensus as to the most suitable fluid to use. While recommendations and suggestions have been made in Europe, America and Asia, there is little or no information about Nigeria and sub Saharan Africa, where the climate is different. This study investigated the plasma sodium changes in Nigerian children receiving 4.3% dextrose in 0.18% saline and Ringer’s lactate as maintenance fluid in the perioperative period.

2- MATERIALS AND METHODS

2-1. Study Design

This is a prospective hospital based study that was carried out in the Pediatric Surgery unit of the Obafemi Awolowo University Teaching Hospitals Complex, (OAUTHC) Ile-Ife, Osun State, Nigeria.

2-2. Study population

The study targeted children between 2 months and 5 years of age undergoing elective surgical operations. A total of 50 patients were enrolled into this study. One group comprising of 25 patients received 4.3% dextrose in 0.18% saline as maintenance fluid while the other group comprising 25 patients received Ringer’s

Lactate as maintenance fluid in the perioperative period. The patients were randomized into the 2 groups of 25 subjects each by lucky dip balloting.

2-3. Inclusion Criteria

- Patients undergoing elective surgery, who were on NPO for at least 24 hours after surgery.
- Patients within the age of 2 months to 5 years.
- Patients whose parents gave consent to participate in the study.

2-4. Exclusion Criteria

- If the type of surgery was known to be associated with excess ADH secretion (cranial, spinal and thoracic surgery).
- Children with known abnormality of ADH secretion, nephrogenic diabetes insipidus, pituitary or hypothalamic disease, kidney disease, acute or chronic lung disease, or who will be receiving drugs known to stimulate ADH secretion.
- Children on diuretics.
- Children with obstructive uropathy.

2-5. Study protocol

2-5-1. Preoperative Period: At the point the child is instructed to stop oral intake before surgery in the preoperative period, vital signs were recorded and patient catheterised to monitor urine output. The patients were then commenced on either of one of the two intravenous fluids (4.3% dextrose in 0.18% saline or Ringer's Lactate) calculated using the Holliday and Segar's recommendation (5). This preoperative fluid administration was discussed with the anaesthetist team, and agreed upon. The calculated fluid requirement was administered at 100% maintenance with the use of an infusion pump in order to avoid under or over delivery of infusion. At the commencement of fasting 3ml of venous blood and 2ml of urine were collected. Blood and urine sample collection were repeated at induction of anaesthesia. Blood samples were collected into sample bottles containing lithium heparin as anticoagulant, while urine sample was collected into universal sample bottles. The same manufacturer made all intravenous fluid. Intraoperatively, the patients were maintained on either of the two intravenous fluids (4.3% dextrose in 0.18% saline or Ringer's Lactate) that were commenced in the preoperative period at 100% maintenance. Estimated blood loss in the intraoperative period was replaced with the maintenance fluid (volume for volume) provided this is less than the allowable blood loss. Blood and urine samples were collected 2 hours into surgery for surgery lasting more than 2 hours. Postoperatively, the patients were maintained on either of the two intravenous fluids (4.3% dextrose in 0.18% saline or Ringer's Lactate) that were commenced in the preoperative period calculated using the Holliday and Segar's recommendation (5) at 100% maintenance via the same infusion pump. Blood and urine samples were collected at the end of surgery and then every eight hours for the first 24 hours after surgery, except for patients who developed hyponatraemia at any point of sample collection. Patients were on NPO all through this period. All patients that developed hyponatraemia during the course of the study had serum sodium corrected and did not continue the prescribed intravenous infusion for the 24 hours post-operative period (intention to treat). However, these patients results were all analyzed as part as the entire sample size.

2-5-2. Specimen analysis

All blood and urine samples were immediately sent to the laboratory for analysis of sodium and creatinine concentration. A chemical pathologist blinded to the groups from which the samples were taken did all sample analysis. . The plasma and urine sodium was analyzed using the flame photometry method. The fractional excretion of sodium was calculated from plasma and urine concentration of sodium and creatinine. The reference range of sodium in the study facility is 120 - 140mmol/L.

2-6. Ethical consideration

Institutional consent was obtained from the Obafemi Awolowo University Teaching Hospitals Research and Ethical committee. The study was explained in detail to the parents/guardian and their consent obtained to allow their children/ward to participate in the study.

2-7. Data analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 22, and presented as simple frequencies, proportions and standard deviation. Student's t-test is used to test the significance of differences between mean values. Chi-Square was used to test the significance of difference between proportions. The probability value (p) less than 0.05 was considered significant.

3- RESULTS

A total of 50 patients were enrolled for this study, 25(50.0%) of them had 4.3% dextrose in 0.18% saline as maintenance fluid while the other 25(50.0%) were placed on Ringer's lactate as maintenance fluid in the perioperative period. The mean age of the study population was 30.6 ±19.33 months. The mean age of the patients on dextrose saline was 28.72±20.3 months, while the mean age of patients on Ringer's lactate was 32.52± 18.53 months. There was no statistical significant difference between the two groups (p=0.49). The mean weight of the patients, estimated blood loss, fractional sodium excretion, duration of fasting and surgery for patients in both group were all-similar as shown in **Table.1**. The types of surgery done in the two groups were as shown in **Table.2**. There was no statistical significant difference in the type of surgery done in the two groups (p= 0.486).

Table 1: Perioperative variables in the study groups

Variables	Groups	Mean	Standard Deviation	P- value
Weight (kg)	0.18% Saline	12.10	5.12	0.906
	Ringer's lactate	12.28	5.11	
Duration of rehydration before surgery (hours)	0.18% saline	7.1	1.49	0.06
	Ringer's lactate	7.88	1.38	
Duration of surgery (minutes)	0.18% saline	104.32	35.68	0.670
	Ringer's lactate	90.92	34.34	
Fractional excretion of sodium	0.18% saline	1.37	0.228	0.341
	Ringer's lactate	1.45	0.237	
Estimated Blood Loss (ml)	0.18% saline	27.2	16.14	0.959
	Ringer's lactate	27.0	10.80	

Table-2: Types of surgery done in both groups.

Surgery Done	Groups		Total	P-value
	0.18% Saline	Ringer's lactate		
Urologic	10	7	17	0.486
Colorectal	7	8	15	
Other Abdominal	4	9	13	
Others	4	1	5	
Total	25	25	50	

All patients were found to be normonatraemic from the point of commencement of the study, all through the period of fasting, during surgery and at the end of surgery. However, at 8 hours after surgery, 8% of patients on 4.3% dextrose in 0.18% saline were found to have hyponatraemia. This however does not show statistical significant difference in the incidence of hyponatraemia at 8 hours post-operative period (p = 0.15). At sixteen hours after surgery, 5 more patients on dextrose saline developed hyponatraemia. However, for the patients on Ringer's Lactate, 2 of them developed hyponatraemia. There were no statistical significance in the two group (p = 0.066). At the end of the study, one more patient in the group receiving 4.3% dextrose saline developed hyponatraemia, the patient had resection of cystic hygroma lasting about 105 minutes. This puts the proportion of patients with hyponatraemia in this group at 32%. The proportion of patients with hyponatraemia at 24 hours after surgery in the two groups was however statistically significant (p= 0.034) (**Table.3**).

Table-3: Proportion of patients with hyponatraemia in the post-operative period.

8 Hours post-operative	Normonatraemia.		Hyponatraemia		Total	P- value
	Frequency	Percentage	Frequency	Percentage		
0.18% saline	23	92	2	8	25	0.15
Ringer's Lactate	25	100	0	0	25	
16 Hours post- operative						
0.18% saline	18	72	7	28	25	0.066
Ringer's Lactate	23	92	2	8	25	
24 Hours post-operative						
0.18% saline	17	68	8	32	25	0.034
Ringer's Lactate	23	92	2	8	25	

Figure.1 is a line graph showing the mean plasma sodium concentration at every point of sample collection. Both group of patients had a drop in the mean sodium concentration as the study progressed. Patients who were maintained on Ringer's lactate as maintenance fluid even though also had a drop in mean plasma sodium concentration maintained higher mean plasma sodium compared to the group on 4.3% dextrose in 0.18% saline.

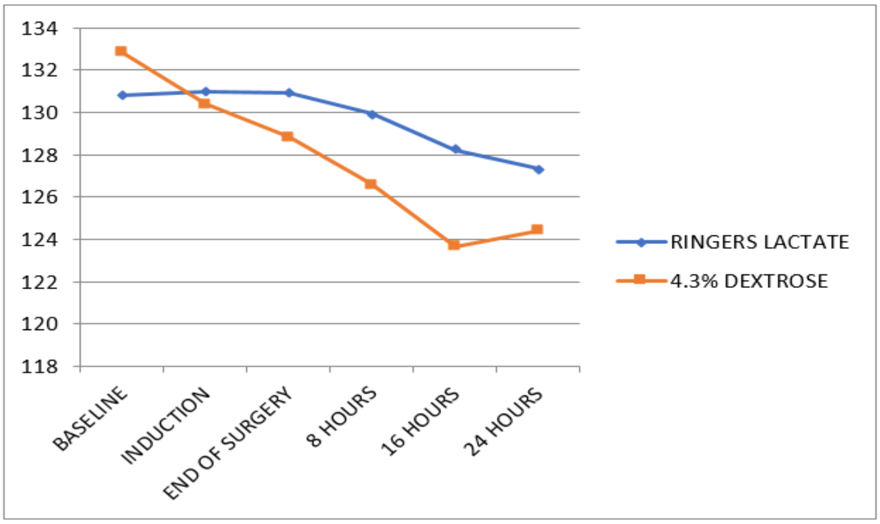

Fig.1: Changes in mean plasma sodium concentration over the duration of the study.

4- DISCUSSION

This study investigated the plasma sodium changes in Nigerian children receiving 4.3% dextrose in 0.18% saline and Ringer's lactate as maintenance fluid in the perioperative period. This study showed that more patients developed hyponatraemia in the postoperative period when placed on 4.3% dextrose in 0.18% saline compared to Ringer's lactate. These differences in proportions reached statistical significance level at 24 hours after surgery. Many studies have demonstrated a higher incidence of hyponatraemia in patients receiving hypotonic fluid (7-9). This study showed that more patients developed hyponatraemia when placed on 4.3% dextrose in 0.18% saline compared to Ringer's lactate. These differences in proportions reached statistical significance level at 24 hours after surgery. Publications have shown that various other studies have demonstrated a higher incidence of hyponatraemia in patients receiving hypotonic fluid (7-10).

The sodium content of the fluid administered has been shown to contribute to the hyponatraemia (11). Au et al. (10) recorded an overall finding of hyponatraemia of 12.9% and 3.4%, respectively among children who were placed on hypotonic and isotonic fluid as maintenance fluid, with an overall incidence of 11%. Though this was a retrospective study it also showed a higher probability of developing hyponatraemia among patients on hypotonic fluid. The proportions of patients with hyponatraemia found in their study were however lower than that found in this study. Choong et al. (7) compared the outcome of the use of 0.45% saline and 0.9% saline as maintenance fluid and got hyponatraemia rates of 40.8% and 22.7%, respectively with a statistical significant difference between the two groups. This finding is higher than the finding in our study despite the fact that the fluids compared in their studies both had a higher concentration of sodium. It still demonstrated a higher probability of hyponatraemia with use of hypotonic fluid. However, unlike this study the age range of patients used were between 6 months to 16 years and the study period extended to 48 hours after surgery. Montanana et al. (9) also did a similar study in hospitalised children and got incidences of hyponatraemia of 20.6% and 5.1% for patient on 0.45% saline and 0.9% saline, respectively. Neville et al. (8) reported hyponatraemia of 30% and 10% for patients on 0.45% and 0.9% normal saline, respectively. This is similar to the finding in this study, which used 0.18% saline and Ringer's lactate instead of 0.45% saline and normal saline respectively. Their study however included children between 7 months and 15 years; and included elective and emergency cases. A third and fourth group of patients in their study who had 50% of daily maintenance of either hypotonic or isotonic fluid were also noted to develop similar incidence of hyponatraemia to those on 100% daily maintenance. They concluded that fluid type (sodium content) and not rate was responsible for hyponatraemia, and that the probability of developing hyponatraemia was higher with use of hypotonic fluid.

Ringer's lactate (an isotonic fluid) with a higher concentration of sodium compared to 4.3% dextrose in 0.18% saline (a hypotonic fluid) appeared to meet the requirement as maintenance fluid in terms of establishing sodium homeostasis. The risk of hyperrnatraemia with use of isotonic fluid is also found to be negligible (7, 9, 10). This was also demonstrated in this study as no patient developed hypernatraemia throughout the study period. The mean plasma sodium concentration was notice to drop in both groups as the study progressed. The patients that were placed on Ringer's lactate demonstrated a higher mean plasma sodium concentration at each point of sample collection. These patients also experienced a less steep drop in plasma sodium concentration with progression of the study. This further supports the fact that sodium content of the fluid has influence on plasma sodium concentration with the probability of developing hyponatraemia higher in patient receiving hypotonic fluid as maintenance fluid. This finding is in keeping with similar publication (8). This study also demonstrated the fact that the use of isotonic fluid as maintenance fluid does not eliminate the risk of developing hyponatraemia. This has also been reported in previous studies (8, 12). This may be explained by the non-osmotic release of anti-diuretic hormone in post-operative patients.

5- CONCLUSION

From this study, isotonic fluid was found to be better as maintenance fluid in preventing perioperative hyponatraemia with little or no risk of developing hypernatraemia. The use of isotonic fluid does not however completely exclude the risk of developing hyponatraemia in the post-operative period. It is recommended that all patients who are on prolonged NPO and maintained on intravenous fluid for as long as 24 hours should have their blood sodium levels monitored.

6- CONFLICT OF INTEREST: None.

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