Original Article

Incidence of Hyponatraemia Following the Use of Three Different Intravenous Fluids in Paediatric Surgery

Casmir Edobor Omoifo, Nosa Philomena Edomwonyi, Sylvester Eshiotseme Idogun[1]

Departments of Anaesthesiology and [1]Chemical Pathology, University of Benin Teaching Hospital, Benin City, Edo State, Nigeria

Abstract

Background: It is a common practice to administer 4.3% dextrose in 0.18% saline peri-operatively and for routine fluid maintenance in the paediatric age group. Concerns have been expressed about the risk of hyponatraemia associated with the administration of hypotonic intravenous fluids, hence the need to re-evaluate our practice. This study aims to evaluate the relative incidence of intra-operative hyponatraemia following the use of isotonic and hyopotonic intravenous fluids. **Patients and Methods:** This randomised double-blind clinical trial recruited consecutive American Society of Anaesthesiologists physical status Class I and II children aged between 6 months and 17 years scheduled for various minor elective surgical procedures. The patients received one of 3 intravenous infusions for intra-operative fluid management. Group I received 4.3% dextrose in 0.18 saline ($n = 25$), Group II received normal saline ($n = 20$) and Group III received Ringer's lactate ($n = 20$). Blood samples were collected before the surgery and at the end of surgery for serum electrolytes. **Results:** One patient in each group developed moderate hyponatraemia intraoperatively. This constituted a 4% (1/25) incidence of intra-operative hyponatraemia among patients who had hypotonic maintenance fluid and a 5% (2/40) incidence in the isotonic maintenance groups. The incidence of hyponatraemia was therefore comparable between patients who had hypotonic and isotonic intra-operative maintenance fluids ($P = 1.000$). **Conclusion:** We conclude that healthy children who have intraoperative hypotonic maintenance fluids during minor elective surgeries are not exposed to the additional risk of hyponatraemia compared to those who have isotonic fluids. The study of a larger sample size is recommended to further validate our findings.

Keywords: Hyponatraemia, intra-operative, intravenous fluids, paediatrics, surgery

Introduction

Hypotonic fluid therapy has been associated with the development of iatrogenic hyponatraemia with increased morbidity and mortality.[1-3] Post-operative deaths have been reported following hypotonic fluid administration.[2-6]

Dextrose 4.3% in 0.18% saline which is routinely used in our environment is hypotonic, hence the need to re-evaluate our practice. The debate on the appropriate intravenous fluids for the paediatric age group continues;[7,8] however, a limited number of randomised studies have been reported.[9] Nevertheless, the weight of expert opinion favours the use of isotonic fluid for maintenance therapy.

This study aimed to determine the incidence of hyponatraemia associated with the intra-operative administration of different intravenous fluids.

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Materials and Methods

After approval was obtained from the institution's Health Research Ethics Committee, this double-blinded randomised trial was conducted. Consent was sought from parents of consecutive American Society of Anesthesiologists (ASA) physical health status Class I or II children aged between 6 months and 17 years scheduled for various minor elective surgical procedures between February and July 2011. Patients were randomly allocated to receive one of 3 intravenous infusions for intra-operative fluid management. This study was conducted over a period of 6 months, and all consecutive cases which met the inclusion criteria were included in the study.

Address for correspondence: Dr. Casmir Edobor Omoifo, Department of Anaesthesiology, University of Benin Teaching Hospital, P.O. Box 2170, Benin City, Edo State, Nigeria.
E-mail: casmiromoifo@yahoo.com

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Patients aged <6 months, emergency surgeries, neurological and other major and extensive surgeries such as exploratory laparotomies and patients for whom intravenous infusions had been commenced before arrival in theatre were excluded from the study.

All patients were evaluated preoperatively by the attending anaesthetist on the day before surgery. Their parents were given detailed information about the study and consent was obtained for eligible patients. On arrival in the theatre on the morning of surgery, a multiparameter patient monitor was attached, and baseline vital signs including pulse rate, blood pressure, oxygen saturation and electrocardiography were obtained and recorded and the patients randomised to receive either of three intravenous fluids for intra-operative fluid management. Group I received 4.3% dextrose in 0.18 saline (n = 25), Group II received normal saline (n = 20) and Group III received Ringer's lactate (n = 20). After randomisation, an intravenous line was secured using an appropriately sized cannula, a blood sample was collected for serum electrolytes, and intravenous fluid was commenced.

The range of normal serum sodium has been defined as 135–150 mmol/L[10,11] with slight variations between laboratories.

Although hyponatraemia has been defined as serum sodium <135 mmol/L,[10,11] sodium concentrations <135, but >130 mmol/L may neither have clinical significance nor require treatment.[12] and are acceptable for elective surgery.[13] For this study, hyponatraemia was defined as moderate when serum sodium was <130 mmol/L without symptoms as this concentration will require close monitoring and treatment.[14] This concentration has also been used to define hyponatraemia by other studies.[15,16] We defined severe hyponatraemia as serum sodium concentration of <125 mmol/L or the presence of symptoms of hyponatraemia associated with a subnormal serum sodium concentration.[12] Symptoms of hyponatraemia include agitation, confusion, lethargy, seizures or even death due to cerebral oedema.[13]

The technique of anaesthesia was left to the discretion of the attending anaesthetists. At the end of surgery, a repeat estimation of serum electrolytes was carried out. The total volume of intravenous fluid administered was documented.

Standard questionnaires were used to document patients' characteristics, type and volume of intra-operative fluid infused, type of surgery, techniques of anaesthesia, and duration of surgery and anaesthesia.

GraphPad InStat version 3 was used for data analysis. ANOVA was used to analyze the parametric data and Chi-square for the nonparametric data. The values of $P < 0.05$ were considered statistically significant.

Results

A total of 65 children were recruited in the study, 25 children (Group I) received 4.3% dextrose in 0.18 saline, 20 children (Group II) received normal saline, and the 20 children (Group III) received Ringer's lactate infusion. The sociodemographic characteristics of the children in the three groups were similar as shown in Table 1.

The surgeries performed were categorised according to the various organ systems on which they were performed as shown in Table 2. General surgical procedures which included procedures such as herniotomies and soft tissue exploration accounted for 27 (41.6%) cases. Orthorynolaryngological cases accounted for 18 (27.69%) cases while orthopaedic and maxillofacial surgeries accounted for 2 (3.08%) cases each. The distributions of fluid type among patients undergoing the various types of surgery were similar (P = 0.078).

The mean volume of each fluid type used for intraoperative fluid management used were similar, (P = 0.59). See Table 3. Intra-operative variables such as estimated blood loss and duration of surgery were also similar in the three groups with P = 0.180 and 0.852, respectively.

One patient in each group developed moderate hyponatraemia intraoperatively. The findings revealed a 4% (1/25) incidence of intra-operative hyponatraemia among patients who had hypotonic fluid for maintenance and a 5% (2/40) incidence in the isotonic groups. With regard to hyponatraemia, there

Table 1: Patient's characteristics

Parameter	Mean±SD			*P*	Level of significance
	4.3% Dextrose saline (*n*=25)	Normal saline (*n*=20)	Ringer lactate (*n*=20)		
Age (years)	6.56±3.70	5.90±3.54	7.00±4.98	0.6907	NS
Weight (kg)	22.77±11.90	24.60±14.98	26.30±17.30	0.7117	NS
Height (cm)	125.79±30.20	120.30±25.10	124.20±29.80	0.8090	NS
Gender					
Male	18 (72.0)	13 (65.0)	16 (80.0)	0.5696	NS
Female	7 (28.0)	7 (35.0)	4 (20.0)		
ASA					
ASA I	23 (92.0)	16 (80.0)	18 (90.0)	0.3496	NS
ASA II	2 (8.0)	4 (20.0)	2 (10.0)		
PCV	30.04±3.45	31.40±7.20	33.79±3.74	0.3014	NS

NS: Not significant, ASA: American Society of Anesthesiologists, SD: Standard deviation, PCV: Packed Cell Volume

was no significant difference in incidence between patients who had hypotonic and isotonic intra-operative maintenance fluids ($P = 1.000$). The pre- and post-operative serum sodium were comparable for the Ringer's lactate, normal saline groups and 4.3% dextrose in 0.18 saline groups ($P = 0.2754$, 0.2850 and 0.2472, respectively).

Discussion

This study suggests that previously healthy children managed with hypotonic (4.3% dextrose in 0.18% saline) or isotonic (0.9% saline, or Ringer's lactate) parenteral maintenance solutions intraoperatively have a comparable risk of developing hyponatraemia. This observation is demonstrated by the similarity in post-operative serum sodium levels in patients who had hypotonic and isotonic fluids, and this is similar to previous reports.[12]

We observed a 4% incidence of intra-operative hyponatraemia in patients managed with hypotonic fluid and a 5% incidence among those managed with the isotonic fluid. This is lower than previously reported.[12,16,17] Some of the reported incidences[12,16] were observed in critically ill patients admitted to the Intensive Care Unit with an increased risk of inappropriate antidiuretic hormone secretion and consequent hyponatraemia. This may have accounted for their observed higher incidence of hyponatraemia compared to our study in which healthy children (ASA I or II) were studied. The higher incidence reported by Eulmesekian *et al*.[17] could be explained by their definition of hyponatraemia as serum sodium <135 mmol/L.

The results of this study did not support previous reports indicating a high risk of iatrogenic hyponatraemia associated with intra-operative hypotonic fluid administration. It is noteworthy, however, that the level of evidence of many of these reports is inadequate to justify a change in the present practice.[1,2,4] A few randomised controlled trials have also reported an increased risk of hyponatraemia associated with perioperative infusion of hypotonic fluids.[18,19]

The study failed to demonstrate a dominant role of hypotonic fluids in the development of hyponatraemia probably because serum electrolyte measurement was not continued beyond the immediate post-operative period unlike in some previous studies.[17-19] This study was restricted to a single post-operative serum sodium estimation as our focus was on the effects of intra-operative fluid management and prolonged post-operative fluid administration was not required in the patients studied as they resumed oral intake within a few hours of surgery. It is important to mention however that symptoms of hyponatraemia such as agitation, confusion, lethargy, seizures or even mortality due to cerebral oedema[13] were not observed in any of the patients in our study before discharge. The patients had minor surgeries and did not require prolonged maintenance fluid administration as the majority of them commenced oral intake within 12 h of surgery. This may have influenced our results as it has been shown that the risk of hyponatraemia with hypotonic maintenance fluid increases with duration of fluid administration.[17]

Although nonosmotic antidiuretic hormone secretion due to stress factors such as pain, fever and surgery have been postulated as a cause of hyponatraemia,[20] All patients were closely monitored, and other predisposing factors to non-osmotic ADH secretion such as pain and hypovolaemia were effectively managed. The possibility of African patients being less stimulated to produce ADH by stressors such as the post-operative state needs to be further investigated.

Conclusion

The incidence of hyponatraemia is comparable between apparently healthy children who have hypotonic or isotonic maintenance fluid during minor elective surgical procedures. The study findings do not support a preference for isotonic maintenance fluids for the intra-operative care of paediatric patients. We, however, recommend further randomised controlled trials with larger study population, ASA III and IV patients and patients scheduled for major surgeries.

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Table 2: Types of surgery

Types of surgery	Frequency (%)
Orthorhynolaryngological surgeries	18 (27.7)
General surgeries	27 (41.6)
Genitourinary surgeries	10 (15.4)
Ophthalmic surgeries	6 (9.2)
Orthopaedic surgeries	2 (3.1)
Maxillofacial surgeries	2 (3.1)
Total	65 (100.0)

Table 3: Pre- and post-operative $Na^+$and K^+ values in the three groups

Parameter	Mean±SD			*P*	Level of significance
	4.3% Dextrose saline (*n*=25)	Normal saline (*n*=20)	Ringer lact (*n*=20)		
Total fluid vol (ml)	384.37±23.20	323.68±213.68	414.74±381.54	0.5979	NS
Preoperative Na^+	136.10±4.68	132.40±3.70	136.38±6.95	0.6963	NS
Postoperative Na^+	134.25±6.36	134.40±6.65	134.29±4.80	0.9965	NS
Preoperative K^+	3.86±0.41	3.90±0.43	3.90±0.61	0.9492	NS
Postoperative K^+	4.07±0.79	3.90±0.28	3.80±0.49	0.3021	NS

NS: Not significant, SD: Standard deviation

Conflicts of interest

There are no conflicts of interest.

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