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Comparison of post-operative acidemia after intraoperative administration of balanced crystalloid plasma – Lyte A® *vis-a-vis* 0.9% sodium chloride in gastrointestinal surgery at a tertiary care hospital in Eastern India

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ABSTRACT

Background: Fluid therapy is the most challenging and debatable aspect of perioperative care. Choice of administrating intravenous fluid perioperative period varies considerably among anesthesiologist. **Aims and Objectives:** The aims of this study were to compare the effects of intraoperative administration of balanced crystalloid solution (Plasma-Lyte A®) and 0.9% sodium chloride (NaCl) on acid–base balance in the post-operative period on patients undergoing gastro intestinal surgery at a tertiary care hospital. **Materials and Methods:** A prospective, randomized, comparative, and observational study was conducted on 80 patients of either sex aged 18–60 years with ASA-I and ASA-II who underwent gastrointestinal surgery which was at first randomly allocated to two equal groups of 40 each. Group 1 received Plasma-Lyte A® as the sole crystalloid and Group 2 received 0.9% NaCl. Intraoperative crystalloid infusion volumes, urinary output, blood loss, and blood transfusion volumes were recorded on hourly basis. Electrolytes (Na^+, K^+) and arterial blood gases were measured after induction of anesthesia and then every hour in the intraoperative period and at the 1st, 6th, and 12th hour of post-operative period. **Results:** The demographic data with respect to age, sex, and type of surgery were comparable among the two groups with no significant difference ($P>0.05$). Intraoperative and post-operative fluid transfusion and blood transfusion were also comparable with no significant difference. On intergroup comparison, serum Na^+ conc. of both the groups was comparable and no difference shown at the time of induction, but after 12 hours following operation, there was a significant increase in Group 2 ($P<0.05$). There was no significant difference in serum K^+ concentration in both the groups except at 6-hour postoperatively, there was an increase in K^+ concentration in Group 1 ($P<0.05$). Serum Cl^- concentration at post-operative 1st, 6th, and 12th hour interval very significantly increased in Group 2 ($P<0.001$). A significant decrease in pH ($P<0.05$) observed in 0.9% NaCl group in comparison to Plasma-Lyte® group when the duration of surgery increased to more than 120 minutes. **Conclusion:** Plasma-Lyte A® and 0.9% NaCl can be used safely during gastrointestinal surgery as the sole crystalloid. However, chance of developing hyperchloremic metabolic acidosis is more with 0.9% NaCl than Plasma-Lyte A® in prolonged surgery exceeding 2 hours.

Key words: Acid–base balance; Crystalloid intravenous fluid; Laparotomy

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INTRODUCTION

The administration of intravenous fluids is one of the most common and universal interventions in medicine. Fluid therapy is the most challenging and debated aspect of perioperative care. The approach to intravenous fluid administration intraoperatively varies considerably between anesthesiologists. In perioperative management during major surgery with blood loss and fluid shifts, maintenance of normovolemia and hemodynamic stability is an important task for anesthesiologists.[1] The primary aim of perioperative fluid administration is to restore normal intravascular volume and improve microcirculatory flow for ensuring adequate tissue oxygenation. The selection and use of resuscitation fluids should be based on physiological principles, but the choice of intravenous fluid during surgery is often arbitrary and a variety of crystalloid solutions with widely differing compositions are employed.

Crystalloid solutions, satisfying basic fluid requirements, and compensating for insensible loses are commonly used in large volumes to support circulation during periods of large fluid shifts.[2] 0.9% sodium chloride (NaCl) solution is commonly used, because it is isotonic with plasma and it has no effect on serum osmolality. Intravenous salt solutions were first used in the 1830 s for the treatment of fluid loss due to cholera.[3] Despite the recognition, nearly, a century ago the infusion of 0.9% saline (often referred to as "normal saline") may cause hyperchloremic metabolic acidosis[4] and the etiology and clinical relevance of this metabolic acidosis remains controversial. It remains the most commonly used intravenous solution in the world. Some investigators call this "Dilutional acidosis," which implies that plasma expansion and dilutional reduction of plasma bicarbonate concentration are the underlying mechanism.[4,5] Solutions containing physiologic levels of chloride and buffer often called "balanced solutions" (e.g., Ringer's acetate, Ringer's lactate, and other multiple electrolyte solutions) are widely available but they are used less frequently than 0.9% saline[6,7].

Aims and objectives

This aim of this study was to examines the effects of intraoperative administration of balanced salt solution i.e. Plasma-Lyte A® (Multiple Electrolytes Injection Type IUSP, Baxter, Gurgaon, India.) and 0.9% NaCl on acid–base and biochemical status in post-operative patients undergoing gastrointestinal (GI) surgery.

MATERIALS AND METHODS

A prospective, randomized, comparative, and observational study was conducted to compare the post-operative effects of intraoperative administration of balanced crystalloid solution (Plasma-Lyte A®) and 0.9% NaCl on acid–base balance on patients of either sex undergoing gastro intestinal surgery at the Department of Anesthesiology and Critical Care, Command Hospital, Kolkata for period of 18 months (January 2016–June 2017). The study was undertaken after obtaining Ethics Committee Clearance as well as informed consent from all patient. Patients aged 18–60 years of age, ASA I and II, undergoing elective gastro intestinal surgery, and willing to give written informed consent were included, whereas any patients receiving diuretic therapy, having a pre-operative bowel washout, pre-operative abnormal electrolyte status, and undergoing major abdominal operations for traumatic injuries were excluded from the study. After using power analysis and considering an effect size of 5, the total sample size was calculated n=80 considering alpha error at 5% and power at 90%. Patient's detailed history of present illness and any other relevant past history of illness were recorded and were randomized into two groups n=40 each using sealed envelopes. Group 1: received balanced crystalloid solution (Plasma-Lyte A®) and Group 2: 0.9% NaCl during and after their respective operations. The patients with >20% blood loss received blood transfusions apart from the study drugs. The composition of 100 ml of intravenous solution: Plasma-Lyte A® (Multiple Electrolytes Injection ype I USP, Baxter, Gurgaon, India) was NaCl IP 526 mg, potassium chloride IP 37 mg, magnesium chloride IP 30 mg, sodium gluconate USP 502 mg, sodium acetate trihydrate IP 368 mg, and water for Injection IP qs. pH 7.4 (6.5–8.0). The concentration of electrolytes in mEq/L was sodium 140, chloride 98, potassium 5, magnesium 3, acetate 27, and gluconate 23, respectively, with osmolarity of 294 mOsmol/L.

Intraoperative monitoring including continuous ECG, intermittent/continuous arterial blood pressure (non-invasive/intra-arterial as indicated), heart rate, oxygen saturation, and end-tidal carbon dioxide was done in all patients, and the values were recorded at an interval of 15 min.

Intraoperative crystalloid infusion volumes, urinary output, blood loss, and blood transfusion volumes were recorded on hourly basis. Electrolytes (Na^+, K^+) and arterial blood gases were measured after induction of anesthesia and then every hour in the intraoperative period and at the 1st, 6th, and 12th h of post-operative period. In the post-operative stage, the same solutions were continuously infused @ 2.0 ml/kg/h until oral intake was allowed for the operated patients.

Statistical methods

Categorical variables were expressed as number of patients and percentage of patients and compared across the groups

using Pearson's Chi-square test for Independence of Attributes/Fisher's Exact Test as appropriate. Continuous variables are expressed as Mean±Standard Deviation and compared across the two groups using Mann–Whitney U-test. The statistical software SPSS version 20 has been used for the analysis. An alpha level of 5% has been taken, that is, if any P<0.05, it has been considered as significant.

RESULTS

A total of n=80 patients were recruited and randomized into two groups into equal number. The mean age, as shown in (Table 1), was comparable. The male-to-female ratio was exactly the same 24:16 in both the study groups. The weight, duration of surgery, intraoperative, and post-operative fluid volume and the amount of blood transfusion required had no statistically significant difference between the two study groups (P>0.05) (Table 1).

Serum sodium concentration of both the groups (Table 2) was comparable and no difference shown at the time of induction, 1 h intraoperatively, 1 h and 6 h postoperatively (P>0.05), but at 12 h postoperatively, there was a significant difference in serum sodium level between the two groups (P<0.05).

Table 3 shows serum potassium concentration in both the groups which were comparable and no difference shown at the time of induction, at 1 h intraoperatively, 1 h and 12 h postoperatively (P>0.05), but postoperatively at 6 h, there was a significant difference in serum potassium level between these two groups (P<0.05).

Table 4 shows no difference in serum chloride concentration in both the groups at the time of induction and at 1 h intraoperatively (P>0.05), but postoperatively at 1, 6, and 12 h, there was a significant difference in serum chloride concentration between these two groups (P<0.05).

In Table 5, the blood pH was depicted in the two groups of patients in whom duration of surgery went beyond 120 min which were comparable and no significant difference (P>0.05) was there at the beginning of the operation, that is, at 1 h intraoperative and 1 h post-operative period. However, after 6 h and 12 h of post-operative period, a significant difference was noted (P<0.05).

The serum bicarbonate concentration in both the study was found to be statistically insignificant at all stages of operation (P>0.05) hence not interpreted in tabular form.

DISCUSSION

The present study was conducted on 80 patients divided equally into groups undergoing GI surgery in a tertiary care hospital receiving either balanced salt solution, for example, Group 1: Plasma-Lyte A® (Multiple Electrolytes Injection Type I USP, Baxter, Gurgaon, India.) or Group 2: 0.9% NaCl to assess the acid–base and biochemical status.

Three patients from Group 1 and two patients from Group 2 required intraoperative blood transfusion. In this study, there were no serious adverse effects in any of the patients of either group.

There were no significant differences between the two groups in respect of age, sex distribution, weight, duration of surgery, and intraoperative and post-operative volume of fluid administered. Pre-operative (at induction) biochemical and acid–base profiles were also comparable.

In our study at 12-h post-operative stage, a statistically significant (P<0.05) difference in serum sodium level was found in the two groups with slight higher concentration in the 0.9% NaCl group. Serum potassium concentration of both the groups were comparable and no difference shown at except at postoperatively at 6 h, the mean concentration in Group 1 was 3.75 mmol/l, whereas, in Group 2, it was 3.59 mmol/l which was found to be statistically significant (P<0.05).

In the contrary, study conducted by Hadimioglu et al.,[8] concluded that no groups experienced any significant changes in serum potassium during the surgery. McFarlane and Lee[9] also found no significant changes in plasma sodium or potassium or blood lactate concentrations in either group. However, Chua et al.,[10] concluded that, patients with DKA resuscitated with Plasma-Lyte had lower Potassium levels at 6–12 h than 0.9% NaCl group.

Table 1: Comparison of the different parameters in the two study groups

Parameters	Group 1 (n=40)	Group 2 (n=40)	P-value
	Mean±SD		
Age (years)	46.48±13.76	50.3±10.43	0.315
Weight (kg)	58.85±9.55	59.63±10.02	0.531
Duration of surgery (minutes)	126±60.51	129.13±71.34	0.626
Intraoperative fluid volume (ml)	1640±918.69	1813.75±930.88	0.371
Post-operative fluid volume (ml)	1491.25±140.46	1487.5±143.56	0.652
Blood transfusion volumes (ml)	35±132.63	35±154.5	0.680

Table 2: Serum sodium level at various stages of operation in both the study groups

Stages of operation	Group 1 (n=40)	Group 2 (n=40)	P-value
	(Mean±SD)		
At Induction	136.8±3.21	136.1±3.75	0.268
Intraoperative (1 h)	137.28±3.64	136.08±3.39	0.165
Post-operative (1 h)	136.33±3.67	135.78±4.07	0.273
(6 h)	135.8±4	136.83±3.81	0.315
(12 h)	135.03±3.95	137.43±4.35	0.028

Table 3: Serum potassium level at various stages of operation in both the study groups

Stages of operation	Group 1 (n=40)	Group 2 (n=40)	P-value
	(Mean±SD)		
At induction	3.73±0.42	3.66±0.42	0.479
Intra operative (1 h)	3.71±0.37	3.69±0.41	0.791
Post-operative (1 h)	3.71±0.31	3.64±0.33	0.301
(6 h)	3.75±0.38	3.59±0.33	0.044
(12 h)	3.74±0.34	3.6±0.31	0.069

Table 4: Serum chloride level at various stages of operation in both the study groups

Stages of operation	Group 1 (n=40)	Group 2 (n=40)	P-value
	(Mean±SD)		
At induction	104.8±3.58	104.88±5.51	0.558
Intra operative (1 h)	103.48±3.42	103.68±4.39	1.000
Post-operative (1 h)	102.43±2.8	106.3±5.34	<0.001
(6 h)	102.43±3.46	106.38±4.17	<0.001
(12 h)	102.68±4.35	107.58±4.92	<0.001

Table 5: Blood pH level at various stages of operation in both the study groups

Stages of operation	Group 1	Group 2	P-value
	(Mean±SD)		
At induction pH	7.46±0.05	7.44±0.05	0.159
Intra operative (1 h)	7.45±0.04	7.42±0.05	0.093
Post-operative (1 h)	7.43±0.03	7.41±0.05	0.240
(6 h)	7.43±0.02	7.4±0.04	0.018
(12 h)	7.43±0.02	7.39±0.04	0.013

In the present study, the mean serum concentration of chloride at post-operative interval of 1, 6, and 12 h was 102.43 mmol/l, 102.43 mmol/l, and 102.68 mmol/l, respectively, for Group 1 and 106.3 mmol/l, 106.38 mmol/l and 107.58 mmol/l, respectively, for Group 2 which were statistically significant (P<0.05). Our this finding had a striking similarities with the other studies conducted by Hadimioglu et al., McFarlane and Lee; Roquilly et al.[8,9,11]

When the bicarbonate level of the patients was assessed, it was observed that there was a gradual decline its level in Group 2 as compared to the other group which was not statistically significant (P>0.05). Although Hadimioglu et al.,[8] and Hasmann et al.,[12] found that maximum decrease in HCO_3-concentration occurred in 0.9% NaCl group and least changes seen with Plasmalyte A.

A statistically significant change in pH was noted in those GI surgeries, where the duration exceeded 120 min in both the study group (P<0.001) in the late post-operative stage, that is, at 6 and 12-h time interval. In this study, the initial mean pH of the two groups was 7.46 and 7.45, respectively. At 1 h intraoperative and postoperatively at 1, 6, and 12 h, also no statistically significant difference in pH was observed (P>0.05). The mean pH in Group 1 changed from initial 7.46–7.43, whereas the mean pH in Group 2 changed from initial 7.45–7.42 at the end of the studies. From the above data, it could be said that, although in both the groups, the pH decreased, but there was no statistically significant difference.

However, when the pH values of the two groups were compared in the perioperative period, where duration of surgery was done for >120 min, there was a significant difference between two groups. The mean pH in Group 1 changed from initial 7.46–7.43, whereas the mean pH in Group 2 changed from initial 7.44–7.39 at the end of the studies. In this case, the pH was gradually decreased, but it was more and statistically significant in 0.9% NaCl group than Plasma-Lyte A®, although acidosis was not present in neither group. This result was similar to the study conducted by Hadimioglu et al., Roquilly et al., and Hasmann et al.,[8,11,12] also found in their study that the pH was lower in the 0.9% NaCl group than in the balanced group.

Hadimioglu et al.,[8] showed that there was a statistically significant decrease in pH (7.44+0.50–7.36+0.05), in patients receiving 0.9% NaCl during surgery but no patients developed acidosis despite the hyperchloremia. pH did not change significantly in the other two groups receiving lactated Ringer's, or Plasmalyte. Development of acidosis is a consequence of central filling volumes, the composition of plasma and extracellular fluids, as well as the rate and composition of fluid losses. The short duration of surgery in their patients and low blood loss also likely contributed to the relatively stable pH during surgery which is similar to our study also.

Limitations of the study

The study planned on selective patients undergoing only gastrointestinal surgery and did not include other type in surgeries.

CONCLUSION

It can be concluded from this study that both Plasma-Lyte A® and 0.9% NaCl can be used safely during gastrointestinal

surgery as the sole crystalloid. However, chance of developing hyperchloremic metabolic acidosis is more with 0.9% NaCl than Plasma-Lyte A® in prolonged surgery sustaining more than 120 minutes.

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