A Comparison of Plasma-lyte A vs 0.9% Saline for Intraoperative Fluid Replacement in Abdominal Surgeries

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ABSTRACT

Introduction: Intra-operative use of 0.9% Saline has been associated with metabolic abnormalities and other adverse outcomes. The primary aim of the study was to evaluate intraoperative use of Plasma-lyte A and 0.9% Saline in terms of mean change in arterial pH, standard bicarbonate, base deficit and serum electrolytes immediate postoperatively and 24 hours after surgery. The secondary aim was to know the impact of fluid type on 24 hour urine output and length of hospital stay after surgery.
Material and Methods: 60 patients of ASA grades I and II of either sex, between 20 to 65 years of age were included and randomly allocated into two groups. They received either intravenous Plasma-lyte A or 0.9% Saline during surgery at the rate of 15 ml/kg/hr. Arterial blood gas and serum electrolytes were measured preoperatively, immediate postoperatively, 24 hours after the surgery and analyzed with 'unpaired t –test'.
Results: Patients receiving Plasma-lyte A had higher mean pH (7.40$\pm$0.05) and lower levels of serum chloride (96.02$\pm$10.16 mmol/l) when compared with those receiving 0.9% Saline (7.32$\pm$0.05 and 117.31$\pm$24.84 mmol/l) in the immediate postoperative period. There was no significant difference seen amongst the groups after 24 hours. No significant difference was observed in 24 hr urine output at postoperative day one as well as mean duration of hospital stay.
Conclusion: In healthy patients both Plasma-lyte A and 0.9% Saline can be safely considered for intraoperative usage due to lack of impact on long term profile. However in the immediate postoperative period, Plasma- lyte A maintained a more physiological picture of acid base balance.

Keywords: Plasma-lyte A, 0.9% Saline, intraoperative fluids, serum electrolytes.

INTRODUCTION

Commencement of intravenous (IV) fluids is usually the first step in any anaesthetic or surgical procedure. Perioperative IV fluid administration is nearly a universal practice where it is necessary to replace as well as maintain intravascular volume which is usually depleted due to perioperative fasting, surgical blood loss, evaporation, urinary excretion, vasodilatation caused by anaesthesia, loss of fluid into the third space and transcapillary leak of albumin caused by mediators of inflammation.[1] Adequate volume of blood is required for sufficient transport of oxygen as well as the nutrients. There can be significant morbidity and mortality due to mistakes in fluid and electrolyte administration.[2,3] Thus, to maintain micro as well as macro haemodynamics and to avoid interstitial fluid overload, IV fluids should be used wisely.[4]
There are different types of IV fluids available which can be broadly divided into crystalloids and colloids. Crystalloids form true solution and are capable of passing through semipermeable membranes. They may be isotonic, hypertonic or hypotonic. Based on the electrolyte composition of the fluid relative to the human plasma, these fluids may be categorized as unbalanced or balanced crystalloids. Most crystalloids consist of non physiological mixture of electrolytes.[5] Composition of electrolytes in plasma are sodium 136-145 mmol/l, chloride 98-108 mmol/l, potassium 3-5 mmol/l, magnesium 1.6-2.4 mmol/l, bicarbonate 21-30 mmol/l and having osmolarity of 294 mosmol/l.
Colloids have high molecular weight and they draw fluid into the intravascular compartment due to oncotic pressure. They are retained in the intravascular space as they contain macromolecules, appropriately called plasma expanders. e.g. albumin, hydroxyethyl starch (HES), hetastarch, pentastarch, plasma and dextran. Use of large amount of these colloids may be associated with unwanted electrolyte or acid base disturbances and coagulation disturbances as almost all colloids are prepared in non-physiological solutions and can be defined as unbalanced colloids.[4]
Crystalloids are preferred over colloids because of lesser cost, easy availability and lack of proven survival benefit of colloids over crystalloids.[6] Most commonly used crystalloid is 0.9% saline. It contains 154 mEq/l of sodium and 154 mEq/l of chloride. Concentration of chloride in 0.9% saline is supraphysiological, almost 50% higher than in plasma (correctly called unbalanced crystalloid). Strong ion difference (SID) of the ECF is around + 40, but 0 in 0.9% saline, so its infusion causes acidosis by decreasing SID according to the Stewart's hypothesis. This decrease in blood pH, increase in chloride levels, decrease in bicarbonate and strong ion difference is known as hyperchloraemic acidosis.[7] Administration of large volumes of saline in healthy individuals' results in persistent hyperchloraemia and decrease in SID. Chloride rich fluids and consequent hyperchloraemia have adverse effects on clinical outcomes in postoperative and critically ill patients. Further, this alteration in acid base balance causes many ill effects as a normal level of bicarbonates and hydrogen ions in plasma is necessary for important functions such as enzyme activity, chemical reactions within the cells, force of cardiac contraction, haemoglobin saturation with oxygen, oxygen delivery, tissue oxygenation, vascular response to catecholamines and many

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How to cite this article: Veena Chatrath, Ranjana, Jaspreet Kaur Walia, Anu Sharma, Harjinder Kaur. A comparison of Plasma-lyte a vs 0.9% Saline for intraoperative fluid replacement in abdominal surgeries. International Journal of Contemporary Medical Research 2016;3(12):3579-3583.

more.

Plasma-lyte A is a balanced salt solution having similar electrolyte constitution to that of plasma. It is not associated with the same disturbance of acid-base status as caused by unbalanced, sodium chloride based fluids. Plasma-lyte A contains 140 mEq/l sodium, 5 mEq/l potassium, 3 mEq/l magnesium, 98 mEq/l chloride, 27 mEq/l acetate, and 23 mEq/l gluconate and osmolarity is 294 mOsmol/L. Lower chloride content of plasma-lyte A tends to attenuate the reduction in the strong ion difference as compared with saline infusion.[8,9] So, we developed hypothesis that 0.9% Saline solution's use in major abdominal surgeries would have detrimental effects and Plasma-lyte A may have a better metabolic outcome. Since very few studies are available on comparison between 0.9% Saline and Plasma-lyte A, this study was conducted to elicit the effect of 0.9% Saline use on arterial blood gas analysis and serum electrolytes in abdominal surgeries as compared to more physiological fluid Plasma-lyte A.

MATERIAL AND METHODS

Approval was obtained from the institutional research and ethics committee. Patients of ASA (American Society Of Anaesthesiologists) grades I and II of either sex between 20 to 65 years of age who were admitted for elective abdominal surgeries were included and divided randomly into two groups of 30 each. Our study included surgeries of comparable duration and comprised of pyeloplasty, pyelolithotomy, nephrectomy, ureterolithotomy, gastrectomy, bzilroth's gastrojejunostomy, splenectomy, hemicolectomy and open cholecystectomy with bile duct exploration. Those patients with ASA grade III and above, having severe renal impairment, cardiac disease, coagulopathy, patients with impaired acid base status and electrolytes were excluded from the study.

Preoperative baseline vitals (heart rate, SpO_2, ECG, respiratory rate, non invasive systolic and diastolic blood pressure) of the patients were recorded. Venous and arterial samples were sent for serum electrolyte measurement and arterial blood gas analysis. After first arterial sample, the test fluid was started in the intravenous line at a pre-decided rate.

Allocation of Groups

Patients were randomly divided into two groups of 30 each using a computer randomization program.

Group A: 30 patients received intravenous plasma-lyte A intraoperatively under general anaesthesia at the rate of 15ml/kg/hr.

Group B: 30 patients received intravenous 0.9% Saline intraoperatively under general anaesthesia at the rate of 15ml/kg/hr.

The study solutions were covered by a paper slip and person who observed and monitored the patient was blinded to the category of fluid being administered. Attending anaesthesiologists and surgeons were also blinded to group assignments. Surgery was allowed to start under general anesthesia taking adequate care of vitals according to institutional protocol. Blood was transfused in those patients in which blood loss exceeded 20% of the estimated circulating volume. Arterial blood gas analysis and clinical chemistry i.e. serum sodium, potassium and chloride were done after completion of surgery (immediate postoperatively) and 24hours postoperatively.

After completion of surgery, the study fluids were stopped and 5% dextrose or 0.45% dextrose normal saline was transfused according to surgical ward protocol. 24 hour urine output following surgery and length of hospital stay defined as time in days following surgery to the day of discharge were measured.

STATISTICAL ANALYSIS

The data from the study was systematically collected, compiled and statistically analyzed to draw relevant conclusions. Statistical analyses were done using Statistical Package for Social Sciences version 21.0 for windows (SPSS IBM Corp Armonk NY, 2012). Demographic and perioperative data were compared using unpaired t-test and χ^2 test. Values were considered to be statistically significant at $p < 0.05$. The power of the study was calculated taking alpha error of probability as 0.05 and was found to be 94%.

RESULTS

Both the groups were found to be comparable for patient's characteristics i.e. age, sex, ASA grading and duration and types of surgery. Pre-operative arterial blood gas analysis and serum electrolyte values including pH, $PaCO_2$ (partial pressure of carbon dioxide), bicarbonate, base excess (BE), serum sodium, serum potassium and serum chloride were also similar in the two groups.

Mean change in pH for group A from baseline to immediate postoperative period was 7.37$\pm$0.28 to 7.40 $\pm$ 0.05 and for group B was 7.36$\pm$0.44 to 7.32$\pm$0.05. Statistically significant difference ($p < 0.001$) was observed for immediate postoperative period between the groups. Mean change in base excess and arterial bicarbonates in group A was -2.24 $\pm$1.34 to -2.34 $\pm$ 1.51 mmol/l and 22.36 $\pm$ 1.95 to 22.26$\pm$ 1.60 mmol/l respectively, whereas in group B there was a decrease in base excess (-1.67$\pm$1.67 to -4.93$\pm$ 3.04 mmol/l) and arterial bicarbonate values (22.03$\pm$ 1.95 to 20.15 $\pm$ 2.34 mmol/l). Graphical trends of these values are shown in Figure 1. In group B there was an increase in serum chloride levels immediate postoperatively (103.79$\pm$ 6.06 to 117.31 $\pm$24.84 mmol/l) whereas in group A serum chloride values were in the physiological range (101.47 $\pm$6.16 to 96.02 $\pm$ 10.16 mmol/l), the difference was significant between the two groups ($P < .001$). Serum sodium levels also increased in group B in the immediate postoperative as compared to group A. Fluctuations in $PaCO_2$ and serum potassium levels remained in physiological range in the two groups. Mean 24 hr urine output in group A was 1824.66$\pm$609.88 ml and group B was 1660.66$\pm$269.09 ml ($P = 0.207$). Length of hospital stay was also comparable between the two groups with mean duration of 5.30$\pm$1.48days in group A and 5.80$\pm$1.80days in group B ($p=0.285$). Mean values and standard deviations of various parameters are shown in Table 1.

DISCUSSION

Isotonic crystalloid solutions are usually the first choice of fluid for volume restoration, but different crystalloid solutions can impact electrolyte and acid base balance differently. In this study we compared the effect of intravenous administration of Plasma-lyte A with that of 0.9% Saline on acid-base and biochemical parameters in elective abdominal surgeries by comparing arterial blood gas analysis for pH, $PaCO_2$, standard bicarbonate, base excess and serum electrolytes i.e. sodium,

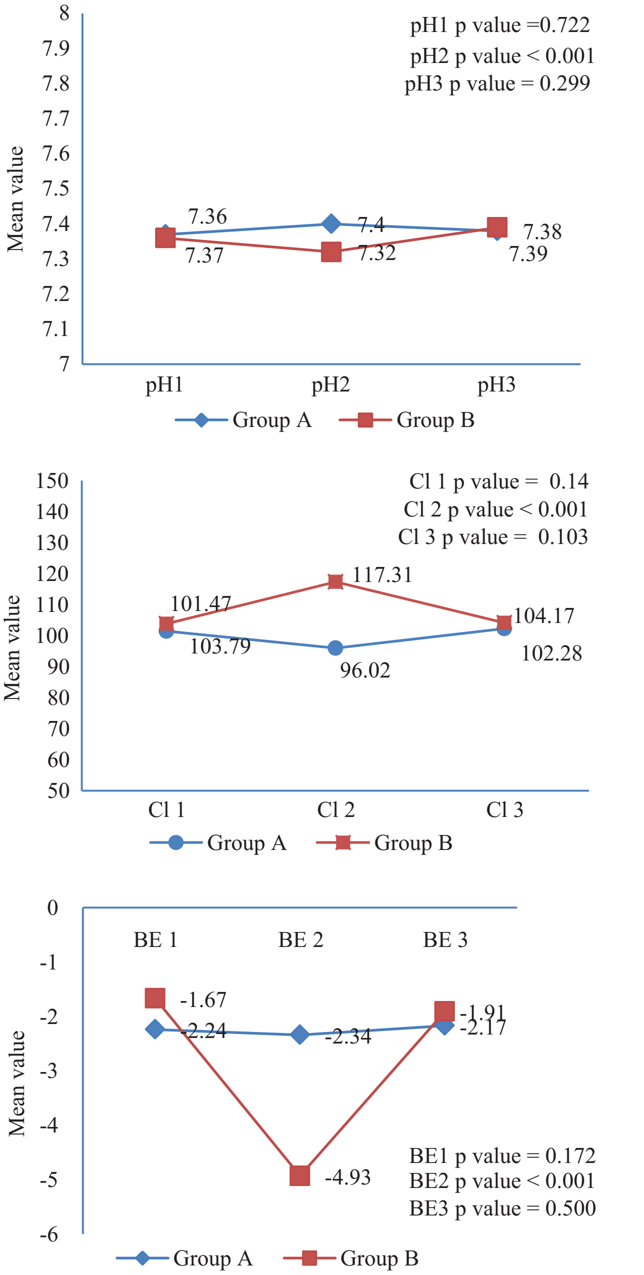

Figure-1: Graphs showing change of pH, serum chloride (Cl) and base excess (BE); (1) first reading taken before starting of surgery; (2) second reading taken immediately postoperatively; (3) third reading taken 24 hr after surgery

Parameter	Group	Mean	SD	'p' value
Na^+ 1	A	137.67	6.19	0.655
	B	136.95	6.19	
Na^+ 2	A	134.89	4.25	0.001
	B	139.51	5.28	
Na^+ 3	A	135.16	2.76	0.084
	B	136.46	2.96	
K^+ 1	A	3.69	0.33	0.053
	B	3.76	0.60	
K^+ 2	A	3.92	0.65	0.305
	B	3.77	0.46	
K^+ 3	A	3.80	0.50	0.637
	B	3.75	0.30	
$PaCO_2$ 1	A	41.08	7.34	0.165
	B	38.33	7.79	
$PaCO_2$ 2	A	38.62	8.37	0.224
	B	40.93	6.02	
$PaCO_2$ 3	A	40.35	6.57	0.404
	B	38.98	6.04	

1: first reading taken before starting of surgery
2: second reading taken immediately postoperatively
3: third reading taken 24 hr after surgery

Table-1: Mean values and standard deviations of serum electrolyte levels and arterial pressure of carbon dioxide observed, and p value between the two groups.

potassium and chloride. Primary outcome of the study was that patients receiving 0.9% Saline as intraoperative fluid had lower pH, base excess, and bicarbonates and higher serum chloride and sodium levels in the immediate postoperative period than those receiving Plasma-lyte A. The noted difference diminished over 24 hrs. Secondary outcomes including 24 hr urine output on post operative day one and length of hospital stay were comparable in the two groups.

Our results were consistent with those of study done by C. Mcfarlane and A. Lee. In comparison of plasma-lyte 148 and 0.9% Saline for intraoperative fluid replacement in patients undergoing hepatobiliary or pancreatic surgeries, they found that 0.9% Saline group had significantly increased plasma chloride concentrations, decreased standard bicarbonate concentration and increased base deficit compared to those receiving plasma-lyte 148 at the end of surgery. The plasma chloride concentrations returned to baseline levels by the end of 24 hours.[10]

S.Y.Kim in 2013 compared 0.9% Saline and Plasma-lyte in living donor kidney transplantation. They found that saline group showed significantly lower values of pH, BE and effective strong ion differences during the post-reperfusion period when compared to plasma-lyte. This group had hyperchloraemic metabolic acidosis. Early postoperative graft functions in terms of serum creatinine, urine output and graft failure requiring dialysis were not significantly different between the groups.[11]

A prospective randomized double blind study was conducted by Hadimioglu et al in 2008. They compared an acetate buffered balanced crystalloid to lactated ringer's solution and normal saline in patients undergoing living donor kidney transplantation. They found a significant decrease in pH in the saline group from the baseline (7.44 to 7.36), although acidosis did not occur. pH did not change significantly in the other two groups. There was significant fall in base excess in the saline group (0.4 to -4.9mmol/l). Similarly, only the saline group had statistically significant elevation in serum chloride levels during transplantation surgery (104.2$\pm$ 3.2 to 125.4$\pm$ 3.7mM/l). No significant changes in acid base measures or lactate levels occurred in patients who received Plasma-lyte A. Changes in potassium levels were non- significant in all the groups.[12]

In the year 2011 Shin W.J et al conducted a randomized trial on 104 donors undergoing right hepatectomy for liver transplantation, where donors received LR (n=52) or Plasmalyte (n=52). The lactate concentrations were found to be significantly higher in the LR group 1 hour after hepatectomy than in the Plasmalyte group [4.2 (3.2–5.7) vs. 3.3 (2.6–4.6) mmol/l; P=0.005]. Significantly lower albumin levels, higher peak total bilirubin concentration and prothrombin time were noted in the LR group. However, these mentioned changes in LR group subsided by the first or second post-operative days and there were no apparent complications or prolongation of hospital stay. Authors concluded that non-lactate-containing balanced crystalloid solutions may have important advantages compared to lactated ringer's solution, in living donors undergoing right hepatectomy taking into concern lactate and liver profiles.[13]

Increased plasma chloride concentration has been linked to reduction in GFR by triggering arteriolar vasoconstriction and leading to reduced urine output. Some previous studies have demonstrated that hyperchloraemia can cause renal vasoconstriction with decreased urine output.[14-16] A study was done by Chowdhury et al in 2012 on healthy volunteers and it was found that IV infusion of 2L of normal saline led to reduced mean renal artery flow velocity, renal cortical tissue perfusion and urine output when compared to a chloride–reduced balanced salt solution.[17]

In our study urine output in 24 hrs after surgery was not significantly different between the two groups. Possibly, as the chloride levels returned to normal over 24 hr period of time, our healthy patients with no significant renal impairment were able to handle the increased chloride load well. In a recent prospective randomized study done by Potura E et al in 2015, acetate –buffered balanced crystalloid was compared with 0.9% saline in 150 patients with end stage renal disease. Incidence of hyperkalemia during cadaveric renal transplantation with the two fluids was studied with the secondary aim of incidence of metabolic acidosis and kidney functions. Hyperkalemia occurred in 17 % of patients in saline group and 21% in balanced group (p value = 0.56). They found minimum base excess was significantly lower in the normal saline group compared to the balanced regimen (-4.5mmol/l [-6 to -2.4] vs -2.6 mmol/l [-4 to -1] respectively, p < 0.001). There was a significant trend toward hyperchloraemia in the saline group compared to the balanced crystalloid group. Serum sodium fluctuations were similar (4 mmol/l [3 to 5] vs 3mmol/l [2 to 5] in the two groups(p value = 0.92). In this study also no difference in urine output between the two groups was seen postoperatively.[18]

Length of hospital stay after surgery was measured in our study to have an estimate of impact of choice of intraoperative fluid on long term benefits. Group A had 5.30±1.48 days of mean hospital stay and group B had 5.80±1.80 days. There was no significant difference between the two groups (p value >0.05). Kim JY et al in 2015 did a study to assess relationship between perioperative intravenous fluid administration strategy and acute kidney injury in off pump coronary artery bypass surgery. In this study, the incidence of acute kidney injury, postoperative extubation time and duration of hospital stay was found to be significantly shorter in the renal protective fluid management strategy group(in which they used balanced crystalloid solution and limited amount of HES) than the control group (consisted of 0.9% saline administration).[19]

Another study done by McCluskey et al in 2013 to find the association of hyperchloraemia after noncardiac surgery with increased morbidity and mortality demonstrated that the group which was given 0.9% Saline intraoperatively leading to hyperchloraemia had increased risk of mortality at 30 days postoperatively and had a longer hospital stay compared with patients with normal postoperative serum chloride levels.[20] However, we did not find any significant differences in duration of hospital stay in two groups. This may be due to a relatively small sample size for identifying their association.

Our study had some limitations. Firstly, the duration of surgical procedures in our study was not very long, so the amount of study fluids given was limited. Infusion of larger volume of fluids may give results and biochemical changes which may be sustained for longer periods of time. Few subjects in our study were administered blood products during surgery when surgical blood loss exceeded 20% of the blood volume. This was not taken into account and it may have some confounding effect on the metabolic profile. Further, in this project we gave our experimental fluids only during intraoperative period, after surgery maintenance fluids consisted of 0.45% DNS (dextrose normal saline), Ringer's Lactate, 5% D(dextrose) according to the surgical ward protocol. These mixed fluids administered after surgery could have diluted the effect of Plasma-lyte A vs NS; hence the biochemical benefits with the former were not sustained. This in turn may have added to the results with no significant differences in the 24 hr postoperative outcome.

CONCLUSION

We concluded from this study that both Plasma-lyte A and 0.9% Saline may be used safely intraoperatively in elective abdominal surgeries because of lack of impact on long term metabolic profile in healthy patients. However, Plasma-lyte A maintained a more physiological picture of acid base balance and electrolytes in the immediate postoperative period. These results may not be extrapolated to the patients with ASA grading III or above and should be interpreted with caution. In this regard further studies are required with larger sample sizes.

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Source of Support: Nil; **Conflict of Interest:** None

Submitted: 29-11-2016; **Published online**: 31-12-2016