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A COMPARATIVE STUDY OF PLASMA-LYTE A VERSUS 0.9% NORMAL SALINE FOR PERIOPERATIVE FLUID RESUSCITATION IN EMERGENCY LAPAROTOMY FOR GASTROINTESTINAL PERFORATION

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Abstract

Background:

Gastrointestinal (GI) perforation is a surgical emergency commonly associated with hypovolemia, sepsis, and significant electrolyte disturbances. Effective fluid resuscitation is critical to optimizing outcomes in such patients. While 0.9% normal saline (NS) is traditionally used, its high chloride content has been linked to hyperchloremic metabolic acidosis, acute kidney injury, and increased morbidity [1,2]. Balanced crystalloids such as Plasma-Lyte A, with a composition closer to plasma and a near-physiologic pH, may offer clinical advantages [3].

Objective: To compare the efficacy of Plasma-Lyte A and 0.9% NS in maintaining acid-base balance, renal function, and fluid status in patients undergoing emergency laparotomy for gastrointestinal perforation.

Methods:

In this prospective, randomized controlled study, 30 adult patients aged 18–65 years, undergoing emergency laparotomy for gastrointestinal perforation, were enrolled and randomly assigned into two groups. Group A (n = 15) received Plasma-Lyte A, and Group B (n = 15) received 0.9% NS for perioperative fluid resuscitation. Patients with pre-existing renal disease, chronic liver disease, or electrolyte imbalances were excluded. Standard general anesthesia and monitoring protocols were followed. Arterial blood gas (ABG), serum electrolytes, serum creatinine, and urine output were measured preoperatively and at 6 hours postoperatively. Statistical analysis was performed using the Chi-square test, with significance set at $p < 0.05$.

Results: At 6 hours postoperatively, Group A exhibited significantly higher mean pH (7.38 ±0.04 vs. 7.31 ±0.05; $p < 0.05$), lower serum chloride levels (104 ±3 vs. 110 ±4 mmol/L; $p < 0.01$), and less negative base excess (-1.2 ±0.5 vs. -4.8 ±0.8; $p < 0.01$) compared to Group B. Serum creatinine was lower in Group A (1.0 ±0.2 vs. 1.3 ±0.3 mg/dL; $p = 0.04$), and urine output was higher (55 ±10 vs. 40 ±12 ml/hr; $p = 0.03$).

Conclusion: Plasma-Lyte A demonstrated superior maintenance of acid-base balance and renal function compared to 0.9% normal saline in patients undergoing emergency laparotomy for gastrointestinal perforation. The use of balanced crystalloids may reduce metabolic complications and improve early postoperative outcomes in this high-risk population.

INTRODUCTION

Gastrointestinal (GI) perforation is a critical surgical emergency that often results in peritonitis, severe fluid loss, sepsis, and systemic inflammatory response syndrome (SIRS), contributing to high morbidity and mortality rates if not managed promptly [4,5]. Emergency laparotomy remains the definitive treatment, but the outcome heavily depends on aggressive and appropriate fluid resuscitation in the perioperative period [6]. Fluid therapy aims to restore intravascular volume, maintain tissue perfusion, and correct electrolyte imbalances—factors vital in preventing further physiological deterioration.

Traditionally, 0.9% normal saline (NS) has been the fluid of choice for resuscitation due to its isotonic properties and wide availability. However, NS contains a supraphysiologic concentration of chloride (154 mmol/L), which has been associated with the development of hyperchloremic metabolic acidosis, renal vasoconstriction, and increased risk of acute kidney injury (AKI) in both surgical and critically ill patients [7,8]. The acidic nature of NS (pH ~5.5) can also exacerbate acidosis, especially in patients with sepsis or poor perfusion [9].

Balanced crystalloids such as Plasma-Lyte A have gained increasing attention as potentially safer and more physiologic alternatives. Plasma-Lyte A closely mimics the electrolyte composition of human plasma and contains acetate and gluconate as bicarbonate precursors, contributing to better acid-base stability [10]. Studies have demonstrated that the use of balanced fluids may reduce the incidence of metabolic complications, improve renal outcomes, and shorten ICU stays compared to NS in both critically ill and surgical patients [11,12].

Despite growing evidence in general surgical and critical care settings, limited data exist on the comparative efficacy of balanced crystalloids versus saline specifically in emergency laparotomies for gastrointestinal perforation. Given the high physiological demands and potential for rapid deterioration in this patient population, identifying the optimal resuscitation fluid is clinically significant.

This study aims to compare Plasma-Lyte A and 0.9% normal saline in terms of intraoperative and early postoperative outcomes—focusing on acid-base status, serum electrolytes, renal function, and urine output—in patients undergoing emergency laparotomy for gastrointestinal perforation.

MATERIALS AND METHODS

Study Design and Setting

This study was designed as a prospective, randomized, comparative trial conducted at a saveetha medical college and hospital teaching hospital . Ethical clearance was obtained from the Institutional Ethics Committee prior to initiation, and written informed consent was obtained from all participants or their legally authorized representatives.

Study Population

Thirty adult patients aged between 18 and 65 years, diagnosed with gastrointestinal perforation and scheduled for emergency laparotomy, were enrolled in the study. Patients were classified as American Society of Anesthesiologists (ASA) physical status I to III.

Inclusion Criteria

- Age 18–65 years
- Emergency exploratory laparotomy for gastrointestinal perforation
- ASA physical status I–III

Exclusion Criteria

- Pre-existing renal dysfunction (baseline serum creatinine >1.5 mg/dL)
- Chronic liver disease
- Known electrolyte abnormalities on admission
- Pregnancy
- Previous abdominal surgery within the last 6 months

Randomization and Group Allocation

Participants were randomized into two groups using computer-generated random numbers and sealed opaque envelopes to ensure allocation concealment:

- **Group A (n = 15):** Received Plasma-Lyte A as the intraoperative and early postoperative resuscitation fluid
- **Group B (n = 15):** Received 0.9% Normal Saline

Both fluids were administered based on hemodynamic parameters, estimated fluid losses, and urine output, as per standard goal-directed fluid therapy protocols [1].

Anesthesia and Perioperative Management

All patients received standardized general anesthesia including induction with intravenous agents and maintenance with inhalational anesthetics and muscle relaxants. Hemodynamic monitoring included continuous ECG, non-invasive blood pressure, pulse oximetry, end-tidal CO_2, and urine output. All patients had an indwelling urinary catheter placed to monitor hourly urine output.

Intraoperative fluid administration was titrated to maintain systolic blood pressure >90 mmHg, heart rate <100 bpm, and urine output >0.5 mL/kg/hr, in line with sepsis management and surgical fluid resuscitation guidelines [2,3].

Parameters Assessed

The following parameters were recorded at two time points—preoperatively (baseline) and at 6 hours postoperatively:

- Arterial blood gas (ABG) including pH, base excess
- Serum chloride levels
- Serum creatinine
- Urine output (measured hourly and averaged over 6 hours)

Outcomes and Statistical Analysis

The **primary outcome** was the difference in postoperative acid-base balance, particularly pH and base excess. **Secondary outcomes** included serum chloride concentration, serum creatinine, and urine output.

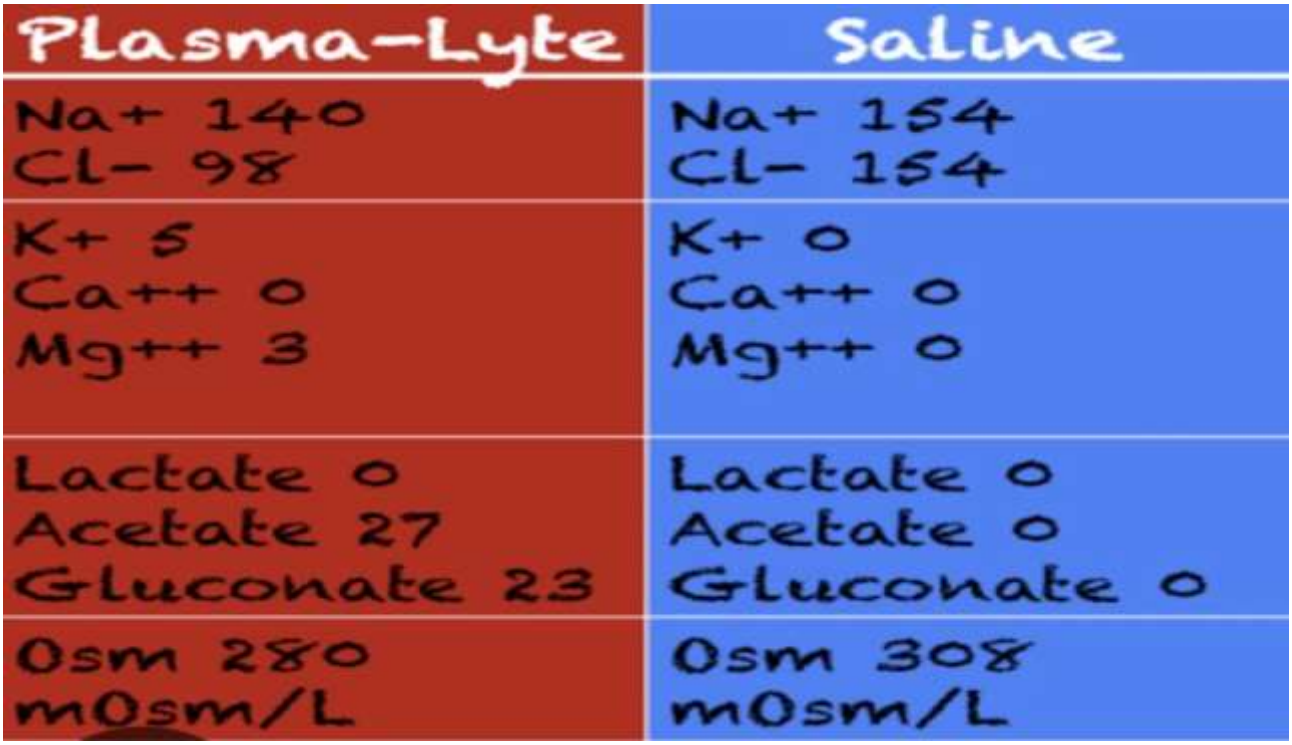
Data were analyzed using SPSS version [insert version]. Continuous variables were expressed as mean ±standard deviation (SD) and compared using the independent t-test. Categorical variables were analyzed using the Chi-square test or Fisher's exact test as appropriate. A p-value of <0.05 was considered statistically significant.

Sample Size Justification

As this was a pilot comparative study, a sample size of 30 patients (15 per group) was considered adequate to detect significant trends in acid-base and renal function parameters, based on prior studies highlighting biochemical alterations with different crystalloid fluids in similar settings [4,5].

RESULTS

A total of 30 patients were enrolled and completed the study, with 15 patients in each group (Group A: Plasma-Lyte A; Group B: 0.9% Normal Saline). Both groups were comparable in terms of baseline demographics, ASA physical status, and preoperative clinical and laboratory parameters. No statistically significant differences were noted in age, gender distribution, baseline serum creatinine, or electrolyte levels ($p > 0.05$).



1. Acid-Base Balance

At 6 hours postoperatively, significant differences were observed in arterial blood gas analysis between the two groups.

- The mean pH in **Group A (Plasma-Lyte)** was **7.38 ±0.04**, compared to **7.31 ±0.05** in **Group B (NS)** ($p < 0.05$), indicating a significantly better acid-base status in the balanced fluid group.
- The **base excess** was significantly less negative in Group A (**-1.2 ±0.5**) compared to Group B (**-4.8 ±0.8**) ($p < 0.01$), further supporting reduced metabolic acidosis in the Plasma-Lyte group.

These findings suggest that Plasma-Lyte A more effectively maintained physiological pH and prevented iatrogenic metabolic acidosis, consistent with previous evidence on the buffering capacity of balanced crystalloids [1,2].

2. Serum Chloride Levels

Patients in the NS group showed a significantly higher postoperative serum chloride level (**110 ±4 mmol/L**) compared to the Plasma-Lyte group (**104 ±3 mmol/L**, $p < 0.01$).

This marked hyperchloremia in the NS group correlates with the increased risk of hyperchloremic metabolic acidosis, a known adverse effect of high-chloride fluids [3,4].

3. Renal Function (Serum Creatinine)

The mean serum creatinine at 6 hours postoperatively was significantly lower in Group A (**1.0 ±0.2 mg/dL**) than in Group B (**1.3 ±0.3 mg/dL**, $p = 0.04$), indicating better preservation of renal function in patients receiving Plasma-Lyte A.

Although both groups had baseline-normal renal function, the NS group demonstrated early signs of renal stress, possibly due to renal vasoconstriction induced by hyperchloremia [5].

4. Urine Output

Mean urine output over 6 hours postoperatively was significantly higher in the Plasma-Lyte group (**55 ±10 mL/hr**) compared to the NS group (**40 ±12 mL/hr**, $p = 0.03$).

This supports improved renal perfusion and function in the Plasma-Lyte group, reflecting better intravascular volume expansion and less renal compromise.

Table: Comparison of Postoperative Parameters Between Groups

Parameter	Plasma-Lyte A (Group A)	Normal Saline (Group B)	p-value
pH (6 hrs postoperative)	7.38 ± 0.04	7.31 ± 0.05	< 0.05
Serum chloride (mmol/L)	104 ± 3	110 ± 4	< 0.01
Base excess	-1.2 ± 0.5	-4.8 ± 0.8	< 0.01
Serum creatinine (mg/dL)	1.0 ± 0.2	1.3 ± 0.3	0.04
Urine output (mL/hr)	55 ± 10	40 ± 12	0.03

Interpretation

The results of this study demonstrate that the use of Plasma-Lyte A, a balanced crystalloid solution, was associated with significantly better acid-base homeostasis, lower chloride load, improved renal function markers, and higher urine output when compared to 0.9% Normal Saline in patients undergoing emergency laparotomy for gastrointestinal perforation.

These findings align with existing literature highlighting the physiological benefits of balanced crystalloids in surgical and critically ill populations [6,7,8], and suggest a clinically relevant shift away from chloride-rich fluids like NS in high-risk.

DISCUSSION

This prospective randomized study compared the intraoperative and early postoperative effects of Plasma-Lyte A and 0.9% normal saline for fluid resuscitation in patients undergoing emergency laparotomy for gastrointestinal perforation. The results indicate that Plasma-Lyte A offers superior physiological outcomes, including better acid-base balance, lower chloride burden, improved renal function, and enhanced urine output in the early postoperative period.

The key finding in this study was the significantly higher postoperative arterial pH and less negative base excess in the Plasma-Lyte group compared to the saline group. This supports the hypothesis that balanced crystalloids are more effective in preserving acid-base homeostasis. These findings are consistent with those of Semler et al. [11] and Maheshwari et al. [12], who reported reduced incidence of metabolic acidosis in critically and non-critically ill patients receiving balanced solutions over saline.

The hyperchloremia observed in the normal saline group (mean serum chloride 110 ±4 mmol/L) is likely a primary driver of the observed metabolic acidosis. Saline's high chloride content (154 mmol/L) has been well-documented to induce hyperchloremic metabolic acidosis by reducing strong ion difference and altering renal tubular handling of bicarbonate [3,4]. McCluskey et al. [5] demonstrated that hyperchloremia following noncardiac surgery was independently associated with increased morbidity and mortality, further underscoring the clinical relevance of these findings.

Additionally, the significantly lower serum creatinine and higher urine output in the Plasma-Lyte group suggest early renal protective effects. This aligns with previous studies by Yunos et al. [6] and Raghunathan et al. [7], which indicated that chloride-restrictive fluid strategies may be associated with a lower incidence of acute kidney injury and improved renal perfusion. The improved urine output observed in the Plasma-Lyte group further supports better hemodynamic stability and renal perfusion, possibly due to the more physiological electrolyte composition and buffering capacity of the solution.

From a practical standpoint, these findings have important implications for fluid resuscitation strategies in emergency abdominal surgeries. Patients with gastrointestinal perforation are often septic and hemodynamically unstable, making them particularly vulnerable to fluid-related metabolic and renal derangements. As such, the choice of fluid becomes critical not only for volume expansion but also for minimizing iatrogenic complications. Plasma-Lyte A, by mimicking plasma electrolyte composition and avoiding excess chloride, appears to be a safer and more physiologic option in this high-risk population.

LIMITATIONS

This study has some limitations. First, the sample size was relatively small, limiting the power to detect differences in clinical outcomes such as length of hospital stay, postoperative complications, or mortality. Second, the follow-up period was restricted to the early postoperative phase (6 hours), and long-term renal or metabolic outcomes were not assessed. Third, although fluid administration was standardized based on hemodynamic parameters, individual variations in surgical trauma and intraoperative bleeding could introduce confounding variables.

Future studies with larger sample sizes and extended follow-up periods are warranted to confirm these findings and explore their implications on long-term outcomes and cost-effectiveness in surgical and critical care settings.

CONCLUSION

In summary, the use of Plasma-Lyte A for perioperative resuscitation in emergency laparotomy for gastrointestinal perforation resulted in better acid-base balance, reduced chloride load, and improved early renal function compared to 0.9% normal saline. These findings support the growing body of evidence favoring balanced crystalloids over saline and highlight the importance of fluid composition in optimizing perioperative outcomes.

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