Original Research Article

Comparative evaluation on the effects of balanced crystalloid solution versus ringer lactate on acid base and electrolyte status in patients undergoing elective neurosurgeries

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Received: 29-11-2021 / Revised: 16-12-2021 / Accepted: 06-01-2022

Abstract

Objectives: To compare the effects of balanced crystalloid solution versus lactated ringer's solution on acid base and electrolyte status in patients undergoing elective neurosurgeries **Materials and methods:** The study was conducted at Ananthapuri Hospitals and Research institute, Thiruvanathapuram A total of 80 patients were enrolled in the study. Randomisation was done using the sealed envelope technique. **Result:** Balanced Crystalloid Solutions provide stable acid base, sodium and potassium levels throughout the perioperative period. **Conclusion:** Being isotonic, Balanced Crystalloid Solutions can be recommended for Neurosurgeries.

Keywords:electrolyte,status

Introduction

Peri-operative fluid administration is an important aspect of surgical care but is often poorly understood. Foremost intravenous fluids (IVF) gained therapeutic importance in the treatment of cholera in the 1830s[1]. Since 1880 IVF began to be administered peri-operatively to compensate for the "injurious" effects of anesthesia. Clinical improvements were consequently noted, though the adverse effects of saline were observed. The most widely used intravenous crystalloid solutions differ considerably from human plasma in composition, tonicity, or both. The most frequently prescribed crystalloid solutions are normal saline and Ringer's lactate solutions. Possible negative effects of these solutions on acid base status and plasma tonicity prompted the development of so-called 'balanced' solution[2].

A balanced electrolyte solution has the physiological electrolyte pattern and infusion of such a balanced solution is devoid of the risk of iatrogenic disruptions except for potential volume overload[2]. As one might expect excessive use of saline has been observed to result in hyperchloremic acidosis which has been identified as a potential side effect of saline based solutions. There is debate about the morbidity associated with this condition, although some consider the associated morbidity is probably low. It has been suggested that the use of balanced solutions may avoid this effect[3].

Materials and methods

The study was conducted at Ananthapuri Hospitals and Research institute, Thiruvanathapuram. Proper institutional Ethics Committee approval was obtained and a written informed consent was acquired from all patients who participated in the study. The study is a prospective observational study for a period of one year (1st June 2014 to 31st May 2015). A total of 80 patients were enrolled in the study. Randomisation was done using the sealed envelope technique, In order to get statistically significant results; a sample size of forty was allocated to each group.

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Inclusion criteria

- ASA physical status I and II.
- Elective neurosurgery of more than two hours duration
- Capable of giving Informed Consent
- Age between 25-65 years.

Exclusion criteria

- Patients with extensive trauma.
- Patients with diabetic ketoacidosis
- Patients with renal failure
- Patients with pre-existing hypotension
- Procedures requiring massive blood transfusion

Sample size (4) was calculated according to the formula:
$Za = 1.96$ for $\infty = 0.05$
$Z\beta = 0.84$ for $\beta = 0.20$
$\mu T = \pi c$ (difference in mean)
σ = pooled standard deviation
Standard deviation of post op base excess (σ) = 2.754
Difference in post op base excess($\triangle$) = 1.8

$$N = \frac{2(1.96 + 0.84)^2 \times 2.754^2}{1.8^2}$$

Final sample size for the study is 37 rounded to 40 in each group
Patients were randomly allocated using the sealed envelope technique into two groups. Sealed opaque envelopes (equal to the number of patients) each containing a card was made. On half the number of cards it was written "Lactated Ringer's Solution "and on the other half it was written "Balanced Crystalloid Solution" indicating the intravenous fluids to be used for the surgery. The envelopes were shuffled and one picked randomly when each patient was taken up.
40 patients received Lactated Ringer's solution and 40 received Balanced Crystalloid solution (Sterofundin). Urine output was maintained at more than 0.5ml/kg/ hr as far as possible.
Baseline arterial blood gas analysis was done to measure pH, pCO^2, bicarbonate and base excess levels. Baseline serum sodium, potassium and chloride levels were also noted. Anesthetic management was standardized to propofol 2.5mg/kg, Fentanyl 2microgram/kg and vecuronium 0.1mg/kg for induction and vecuronium infusion and sevoflurane for maintenance of the patients were monitored via arterial and central venous cathers.

Arterial blood gas analysis and serum sodium potassium and chlorides levels were measured intra-operatively after three hours and post-operatively after one hour and every three hours for the next six hour.

Mechanical ventilation was performed to maintain the arterial oxygen tension at 200-300 mmHg and the arterial carbon dioxide pressure at 35-40 mmHg. Intra-operative monitoring included end tidal carbon-di-oxide, Cardiac electrical activity, Central venous pressure, arterial blood pressure and pulse-oximetry.

Statistical analysis

Descriptive statistics such as percentage, mean and standard deviation were used to describe the variables used in the study. Inferential statistics such as independent test and chi square test was used to test the homogeneity of study variables between study drugs. Independent t test was used to compare outcome variables such as pH, PCO_2 etc at different interval of time between the study groups. SPSS 17.0 version was used to analyse data.

Result

Table 1: Distribution according to American Society of anesthesiologist physical status classifications (ASAPS)

ASA	Lactated Ringer Solution		Balanced Crystalloid Solution			
	Count	Percent	Count	Percent	Z^2	P
Grade I	19	47.5	23	57.5	0.8	0.370
Grade II	21	52.5	17	42.5		

In table 1 the Chi square statistics t Z1 – U^{R-P} – P-005) showed that the groups were compared based on the ASA grading of patients.

Table 2: Comparison of MAP (mmHg) between groups at different time interval

MAP (mmHg)	Lactated Ringer Solution			Balanced Crystalloid			t	p
	Mean	SD	N	Mean	SD	N		
30 Min	65.0	2.1	40	65.4	2.0	40	0.76	0.449
1 hr	65.0	2.1	40	65.5	2.1	40	0.91	0.367
2 hr	64.7	2.1	40	65.2	2.0	40	0.96	0.339
3 hr	65.0	2.1	40	65.4	2.1	40	0.73	0.466

Table 2 shows that the groups were compared based on their MAP in the intra-operative period. The MAP in both groups was stable throughout the surgery.

Table 3: Comparison of CVP (mmHg) between groups at different time interval

CVP (mmHg)	Lactated Ringer Solution			Balanced Crystalloid Solution			t	p
	Mean	SD	N	Mean	SD	N		
30 Min	7.8	1.4	40	8.0	1.4	40	0.72	0.471
1 hr	7.8	1.4	40	7.9	1.4	40	0.56	0.579
2 hr	7.8	1.4	40	8.1	1.4	40	0.82	0.414
3 hr	8.0	1.4	40	8.3	1.4	40	0.88	0.380

In table 3 the groups were compared based on their CVP in the intra-operative period.

Table 4: Comparison of pH between groups at different time interval

pH	Lactated Ringer Solution			Balanced Crystalloid Solution			t	p
	Mean	SD	N	Mean	SD	N		
Pre Op	7.42	0.06	40	7.43	0.04	40	1.41	0.162
Intra Op after 3 Hrs	7.41	0.07	40	7.41	0.06	40	0.39	0.698
Post op 2nd Hr	7.43	0.09	40	7.44	0.09	40	0.6	0.547
Post op 5th Hr	7.42	0.09	40	7.42	0.08	40	0.38	0.704
Post op 8th Hr	7.45	0.07	40	7.44	0.08	40	0.5	0.621

Table 4 shows that he mean pH does not differ between two groups at all time intervals (0.05)

Table 5: Comparison of $PaCO^2$ between groups at different time internal

$PaCO_2$ (mmHg)	Lactated Ringer Solution			Balanced Crystalloid Solution			t	P
	Mean	SD	N	Mean	SD	N		
op	36.14	7.26	40	37.01	6.04	36.14	0.58	0.039
after 3 Hr	35.24	6.88	40	38.46	6.86	35.24	2.1	0.994
2nd Hr	31.26	8.34	40	31.25	7.48	31.26	0.01	0.159
5th Hr	33.16	7.84	40	35.57	7.29	33.16	1.42	0.391
8th Hr	33.03	6.85	40	34.28	6.12	33.03	0.86	0.393

Table 5 shows that $PaCO^2$ levels were measured intra operatively after three hours and respectively after one hour and every three hour from the next six hours

Table 6: Comparison HCO_3- between groups at different time interval

HCO_3-	Lactated Ringer Solution			Balanced Crystalloid Solution				
	Mean	SD	N	Mean	SD	N	I	P
Pre Op	23.41	3.34	40	24.59	213	40	188	0.064
Intra Op after 3 Hrs	22.66	2.83	40	23.95	2.93	40	24	0.049
Post 2nd Hr	21.37	3.28	40	22.71	3.60	40	174	0.086

Post 5th Hr	22.56	3.70	40	23.17	3.99	40	071	0.480
Post 8th Hr	23.38	3.16	40	24.12	3.04	40	107	0.289

Table 6 shows that in Lactated Ringer Solution group, mean HCO3- value is less when compared to Balanced Crystalloid Solution in all ABG samples but the difference is statistically significant (p value = 0.049) in intra operative samples.

The HCO3- level decreases in intra operative period and post-operative 2nd hour samples. The decrease was maximum in postoperative 2nd hour samples in both groups. Then HCO3- levels gradually increases to reach the preoperative level during 8th hour of post-operative period. In Balanced crystalloid solution group HCO3- values were within the normal range.

Table 7: Comparison of Base Excess between groups at different time interval

Base Excess (mEq/L)	Lactated Ringer Solution			Balanced Crystalloid Solution				
	Mean	SD	N	Mean	SD	N	I	P
Pre Op	-1.16	3.50	40	0.28	3.13	40	1.93	0.057
Intra Op after 3Hrs	-2.2	3.3	40	-0.8	3.5	40	1.95	0.055
Post 2nd Hr	-3.5	3.9	40	-2.2	3.9	40	1.43	0.156
Post 5th Hr	-2.5	4.2	40	-1.7	4.4	40	0.77	0.442
Post 8th Hr	-1.2	3.3	40	-0.6	3.5	40	0.8	0.424

Table 7 shows that base excess decreases during intra operative and postoperative period samples in both the two groups. The decrease is more for the Lactated Ringer solution group but the difference is not statistically significant. The decrease in base excess was maximum in the 2nd hour of postoperative period in both the groups.

Table 8: Comparison of Na+ between at different time interval

Na+ (mEq/L)	Lactated Ringer Solution				Balanced Crystalloid Solution			
	Mean	SD	N	Mean	SD	N	I	P
Pre Op	138.3	5.4	40	138.0	5.1	40	0.28	0.784
Intra Op after 3 Hrs	138.3	4.7	40	138.1	6.7	40	0.17	0.862
Post 2nd Hr	132.7	67	40	132.2	9.0	40	0.28	0.779
Post 5th Hr	129.9	5.9	40	131.9	7.3	10	1.33	0.189
Post 8th Hr	130.4	4.3	40	132.9	8.1	40	1.73	0.087

Table 8 shows that serum sodium level decreases in the postoperative period in both the groups. The mean serum sodium does not differ between the two groups.

Table 9: Comparison of K+ between groups at different time interval

K+ (mEq/L)	Lactated Ringer Solution				Balanced Crystalloid Solution			
	Mean	SD	N	Mean	SD	N	I	P
Pre Op	3.6	0.6	40	3.5	0.5	40	0.79	0.434
Intra Op after 3 Hrs	3.6	0.5	40	3.6	0.5	40	0.31	0.761
Post 2nd Hr	3.4	0.9	40	3.3	0.6	40	0.98	0.330
Post 5th Hr	3.3	0.6	40	3.3	0.7	40	0.11	0.915
Post 8th Hr	3.5	0.5	40	3.4	0.6	40	0.23	0.820

Table 9 shows that the difference in mean serum potassium between the two groups in all time intervals was not statistically significant.

Cl-(mEq/L)

Table 10: Comparison of Cl- between groups at difference time interval

Cl-	Lactated Ringer Solution				Balanced Crystalloid Solution			
	Mean	SD	N	Mean	SD	N	I	P
Pre Op	100.2	4.0	100.4	5.4	40	0.21	0.98	0.832
Intra Op after 3 Hrs	99.9	3.9	40	100.4	6.0	40	0.46	0.649
Post 2nd Hr	97.3	7.4	40	95.3	9.4	40	1.97	0.289
Post 5th Hr	92.6	7.2	40	95.2	7.4	40	16	0.115
Post 8th Hr	93.4	6.2	40	95.6	7.3	40	1.47	0.146

In table 10 the serum chloride decreases in the postoperative periods in both the groups. The different in mean serum chloride between the two groups is not statistically significant.

Discussion

The present study was designed to compare the effect of Lactated Ringer's Solution and Balanced Crystalloid Solution (sterofundin) on intra operative and post operative acid base status and serum electrolyte changes mainly sodium, potassium and chloride levels.

This was done by analysis of a sample of arterial blood for taking the values of blood for HCO^-, base excess, Na^+ K^+ and Cl^- values. The blood gas analysis is done at preoperative period, intra operative period after 3 hours and post operative 2nd 5th and 8th hour samples.

80 patients were included in the study and 40 received Lactated Ringer's solution, the rest 40 received balanced crystalloid solution (Sterofundin). The anesthetic technique was same in all the cases.

The results of our study shows that sterofundin may be superior to Lactated Ringer's solution in terms of maintaining pH balance providing a more stable acid base profile and reducing risk of hypernatremia which is in concurrence with the study done by Padmapriya et al.[5]. Whereas there is no statistically significant difference in pH profile and serum sodium status between Balanced Crystalloid solution and Lactated Ringer's Solution group were noted in our study.

The difference in mean $PaCO^2$ during intra operative period after 3 times is statistically significant (0.039) but the value appear to the in conge in both the two groups. The mean $PaCO^2$ at postoperative periods at 2nd hour, 5th hour and 8th hour is less in both the groups, but they are not statistically significant. This may be due to the spontaneous respiratory effort by the patient. Pain and anxiety night

be the reason for hyper ventilation[6]. The MAP and CVP in both groups were stable throughout the surgery.

Unlike the findings of the study done by Potura E.Lindner G et al.[7], where patient had hyperkalemia with administration of acetate buffered balanced crystalloid, our study showed serum potassium values within the normal range in both Balance crystalloid and Lactated Ringer's group. They also noted less hyperchloremia and metabolic acidosis which is in line with the findings of our study.

In our study we had stable acid base profile and lower serum chloride levels for sterofundin group which is similar to the findings of the study done by Disma N.Mameli L.et al.[8,9], who concluded that sterofundin is safer than normal saline in protecting young children undergoing major surgery against the risk of increasing plasma chlorides and subsequent metabolic acidosis.

Likewise our study also reverted lower serum chloride levels in postoperative period for the both Balanced Crystalloid and lactated Ringer group which are significant with the study of EM. Stand T et at.[10], which shows lower serum chloride levels in HES balanced group. The serum potassium levels were not significantly changed in both the groups and acid base profile of balanced crystalloid solution were improved. Similar changes were observed in the study of Hadmioglu N.Saadway et al.[11], where plasma-lyte was used as balanced crystalloid solution.

The inference about Lactated Ringer's Solution in our study proved to be consistent with the findings of Frumento et al.[12], who revealed less hyperkalemia and acidosis in Lactated Ringer group. Both the solutions avoided the development of hyperchloremic metabolic acidosis.

Though various studies were done[13,14,15] comparing lactated Ringer's and Balanced Crystalloid solution because of the potential clinical differences between solutions and the lack of definitive data, a comparative study is planned, on patients insisting the importance of choosing the right fluid for the right patient.

Conclusion

There is a statistically significant difference in the serum bicarbonate level in the intra operative period between Lactated Ringer's solution and Balanced Crystalloid Solution (Sterofundin). Balanced Crystalloid Solution provides a more stable acid base profile, but there is not much difference in pH profile between both the groups probably because of metabolic compensation.

Our study showed stable sodium levels during intra operative and postoperative periods for both Lactated Ringer's Solution and Balanced Crystalloid Solution (Sterofundin) but no statistical significance difference in serum potassium levels in intra operative & postoperative period in both the groups. Also the stable serum chloride levels in postoperative period for both the Balanced Crystalloid and lactated Ringer group reveals the fact that there is no significant hyperchloremic acidosis with both Lactated Ringer's Solution and Balanced Crystalloid Solution (Sterofundin).

Recommendations

- Balanced Crystalloid Solutions provide stable acid base, so it can be recommended for prolonged surgeries and trauma.
- In contrast to other crystalloid solutions, Balanced Crystalloid solutions provide stable sodium and potassium levels throughout the perioperative period.
- Being isotonic, Balanced Crystalloid Solutions can be recommended for Neurosurgeries.
- Since few studies reported Hyperchloremic acidosis while using normal saline, we recommended further studies to compare Normal Saline with Balanced Crystalloid Solutions.
- We recommended Balanced Crystalloid Solutions in patients with hepatic disorders as the metabolizable anion used in Balanced Crystalloid Solution is manly Acetate.

Conflict of Interest: Nil Source of support: Nil

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