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A study on effect of lactate versus acetate-based intravenous fluids on acid-base balance in patients undergoing free flap reconstructive surgeries in India

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Abstract
Introduction: Fluid therapy is very important in managing the recovery of patients from major surgery and trauma. Postoperative fluid management comprises maintenance of fluid, replacement of on-going losses and correction of anemia or hypovolemia. Use of lactated intravenous fluids during long surgeries could cause lactate accumulation and lactic acidosis. We evaluated the comparative effects of administration of lactated versus no lactated solutions on serum lactate levels in patients undergoing free flap surgeries.
Material and Methods: This was a prospective study conducted over a period of 3 years. 72 patients undergoing major head and neck surgeries with free flap reconstruction were recruited. No patient was forced to be a part of the study. Patients with hepatic and renal derangement, congestive cardiac failure, diabetics, and those unwilling to participate after explanation of the protocol were not included in the study.
Result: Mean age of the patients in years in Groups SF and RL was 54.5±18.1 versus 48.2±16.5 (P=0.168) and weight in kg was 64.2±9.8 vs. 59.3±13.1, P =0.196, respectively, hence the demographic variables in both groups were comparable. The distribution of gender and physical status were also comparable.
Conclusion: we conclude that the intraoperative use of Sterofundin is comparable or even better than Ringer’s Lactate in terms of preservation of acid-base and electrolyte balance, avoidance of hypo/hyperglycaemia and cardiovascular stability in patients undergoing moderate to major surgery.

Keywords: Fluid therapy, major surgery, maintenance of fluid, acid-base balance

Introduction
Lactate accumulation and lactic acidosis can be caused due to use of lactated intravenous fluids during long surgeries. Acetate-based solutions are devoid of lactate hence they could be advantageous. Fluid therapy is very important in managingthe recovery of patients from major surgery and trauma. Postoperative fluid management comprises maintenance of fluid, replacement of on-going losses and correction of anaemia or hypovolemia [1]. If early correction of hypovolemia is not done, prolong hypoperfusion can cause organ dysfunction [2]. The anesthetists have to consider carefully the type and amount of intravenous fluid administered intraoperatively. Most of the fluids given Perioperative are used for replacing deficits and third space losses, which consist mainly of extracellular fluid [3]. The primary aim of the study was to assess the effect of use of an acetated solution or Ringer’s lactate (RL) as intraoperative fluid on lactate levels in patients without hepatic dysfunction undergoing prolonged surgeries. Free flap reconstructive surgeries for head and neck malignancies are long procedures requiring hemodilution with relative hypertension to improve perfusion across microanastomoses. Administration of large amount of crystalloids is usually needed to avoid the use of vasoconstrictors. Normally extraneous lactate is completely metabolized by liver, and blood levels are maintained in the range of 0.2–2mmol/L. Short-term infusion of lactated Ringer's solution in normal adults who are haemodynamically stable does not falsely increase circulating lactate concentrations [4]. However Sterofundin may be more beneficial fluid than Ringer's lactate in patients with liver dysfunction [5]. Balanced crystalloids, whose composition prevents hyperchloremia, are increasingly accepted and likely to be ‘state of the art’ in the near future [6-9].

Material and Methods
This was a prospective study conducted over a period of 3 years in department of Surgery with the collaboration of department of medicine.

72 patients undergoing major head and neck surgeries with free flap reconstruction were recruited. No patient was forced to be a part of the study. Patients with hepatic and renal derangement, congestive cardiac failure, diabetics, and those unwilling to participate after explanation of the protocol were not included in the study. On the basis of a previous study by Shariffuddin *et al.* [10] using changes in lactate levels as the objective, with an expected mean difference of 0.52, with 95% confidence,
minimum estimated sample size was calculated as 17 in each group to get statistically significant results.
Twp equal groups of patients were formed randomly by computer-generated sequence to Group SF and Group RL. Both the groups were kept nil per orally, 8h for solids and 2h for clear fluids.
The patients of Group SF were started on acetate-based crystalloid solution (Sterofundin B Braun) and Group RL received RL intravenously at the rate of 10 ml/kg/h to maintain systolic blood pressure (SBP) above 90 mmHg after introducing an arterial cannula under local anesthesia, and taking a baseline arterial blood gas (ABG) sample in the theatre. General anesthesia was given to all the patients with end tracheal intubation and mechanical ventilation following a standardized protocol.
Arterial pH, partial pressures of carbon dioxide, bicarbonate, sodium, potassium, chloride, lactates, and glucose levels were documented, heart rate (HR), SBP, diastolic blood pressure, and mean arterial pressure (MAP) of each patient were noted and documented at preinduction and half hourly intraoperatively. Urine output was documented hourly and core body temperature every 2 hours.

Result

Mean age of the patients in years in Groups SF and RL was 54.5±18.1 versus 48.2±16.5 (P=0.168) and weight in kg was 64.2±9.8 vs. 59.3±13.1, P=0.196, respectively, hence the demographic variables in both groups were comparable. The distribution of gender and physical status were also comparable.
In Table1, Comparison of baseline, pH, pCO_2, bicarbonate, sodium, potassium, lactate, and glucose of both RL and SF groups yielded comparable results. The bicarbonate levels remained comparable whereas lactate levels were significantly high in RL group at 2, 4, 6 and 8h. Except at 8h where RL group had a significantly lower pH than SF group, Intraoperative pH was comparable between groups. Sodium, potassium, chloride, and pCO_2 did not show any significant difference between the groups intraoperatively. Table 2 shows Group Bremained comparable with group SF but at 2h, it had significantly high glucose levels. There was a fall in core body temperature in both the groups from baseline till 8h, but the difference between groups was not statistically significant. Comparison of intraoperative hemodynamics revealed a significantly high HR in Group SF at 4, 6 and 8h with comparable MAP throughout the study period.
The difference was still insignificant although more patients in Group SF developed hypotension and required fluid boluses to correct hypotension as compared to RL group. The blood loss and percentage of patients who required blood transfusion in SF group were similar to those in RL group, the difference was insignificant. Similarly, the total volume of the crystalloid used intraoperatively also did not show any significant difference between the groups. Mean intraoperative urine output per hour in both the groups was comparable. Five patients in SF group and four in RL group required intermittent bolus phenylephrine intraoperatively, and the mean requirement in these patients in both the groups did not show any statistically significant difference.

Table 1: Comparison of pH, lactate, bicarbonate and pCO_2 (Mean±SD) in Groups SF and RL

Time	pH		P
	SF	RL	
Baseline	7.8±0.0	7.8±0.2	0.324
2h	7.8±0.2	7.8±0.0	0.986
4h	7.8±0.0	7.8±0.2	0.321
6h	7.8±0.2	7.8±0.2	0.346
8h	7.8±0.2	7.8±0.2	0.062
	Lactate		
Baseline	1.4±0.8	1.6±0.8	0.096
2 h	1.6±0.9	2.6±0.9	<0.001
4 h	1.6±0.8	3.1±1.6	<0.001
6 h	1.6±0.6	3.2±2.1	<0.001
8 h	1.9±0.7	3.7±1.9	<0.001
	Bicarbonate		
Baseline	24.3±2.4	24.6±1.9	0.636
2 h	23.29±1.9	23.6±2.9	0.971
4 h	24.6±2.6	23.6±2.3	0.372
6 h	23.6±2.8	23.4±2.6	0.763
8 h	23.4±2.6	23.2±2.7	0.221
	pCO_2		
Baseline	38.0±4.4	35.4±4.8	0.221
2 h	36.2±5.1	35.2±4.5	0.678
4 h	36.4±4.8	35.3±4.2	0.456
6 h	36.2±5.6	37.2±5.5	0.687
8 h	36.2±4.8	37.2±3.9	0.534

SD = Standard deviation, RL = Ringer's lactate, SF = Sterofundin

Table 2: Comparison of electrolytes and glucose (Mean±SD) in Groups SF and RL

Time	Sodium		p
	SF	RL	
Baseline	134.8±4.6	135.6±4.4	0.489
2h	136.9±4.6	136.8±4.6	0.956
4h	137.0±4.2	137.2±4.4	0.922
6h	136.4±5.8	135.6±3.4	0.845
8h	136.2±4.8	136.2±4.8	0.912
	Potassium		
Baseline	3.8±0.6	3.9±0.8	0.922
2 h	3.8±0.6	3.8±0.6	0.578
4 h	3.9±0.7	3.8±0.6	0.098
6 h	3.9±0.5	3.9±0.4	0.368
8 h	3.8±0.6	3.9±0.4	0.998
	Chloride		
Baseline	103.6±4.2	104.7±5.9	0.512
2 h	105.2±4.2	106.8±4.3	0.167
4 h	106.8±3.8	108.0±4.6	0.298
6 h	106.4±4.1	106.0±3.7	0.899
8 h	106.1±4.9	106.5±4.3	0.986
	Glucose		
Baseline	113.2±29.4	121.5±37.2	0.380
2 h	124.2±19.2	142.1±35.2	0.031
4 h	144.1±25.0	155.0±45.2	0.310
6 h	146.5±26.6	152.2±40.2	0.598
8 h	152.1±37.7	163.2±29.2	0.246

SD = Standard deviation, RL = Ringer's lactate, SF = Sterofundin

Table 3: Comparison of heart rate mean arterial pressure and temperature (Mean±SD) in Groups SF and RL

Time	Heart rate		p
	SF	RL	
Baseline	88.5±14.6	82.2±13.4	0.078
2h	91.0±11.6	78.6±18.2	0.002
4h	88.4±19.2	74.8±15.6	0.004
6h	84.8±17.8	75.0±12.6	0.012
8h	81.6±15.8	73.9±17.3	0.072
	Mean arterial pressure		
Baseline	95.9±18.0	97.2±18.3	0.833
2h	82.6±13.2	88.7±14.6	0.076
4h	81.2±9.9	85.7±13.5	0.178
6h	83.6±12.8	79.9±10.5	0.234
8h	84.4±16.1	83.4±12.6	0.698
	Core body temperature		
Baseline	36.8±0.6	37.1±0.3	0.098
2h	36.4±0.6	36.2±0.5	0.089
4h	36.2±0.8	35.4±0.9	0.098
6h	35.1±1.3	35.6±1.9	0.297
8h	34.2±0.6	34.6±0.5	0.123

SD = Standard deviation, RL = Ringer's lactate, SF = Sterofundin

Discussion

Head and neck free flap reconstructive surgeries are of long duration with major intraoperative and postoperative fluid and electrolyte loss because of extensive resections and vascular anastomoses. Balanced solutions such as Ringer's Lactate and Sterofundin contain bicarbonate precursors (lactate or acetate), so there may be a possibility for these solutions to produce metabolic alkalosis after larger volumes are administered.[10] A research on hypochloraemic acidosis has revealed that even small changes in pH can have a negative impact on organ systems [11]

Primarily in critically ill patients with ambiguous results and with unclear implications for fluid management in elective surgical procedures, the choice of fluid to administer has been investigated in numerous randomized, controlled trials and systematic reviews [12-16]. Maintenance fluid, fasting deficits, and replacement of any losses occurring in the intraoperative period falls under Intraoperative fluid management [17]. The aim of fluid therapy is to ensure stable intraoperative hemodynamics, improved organ perfusion, and adequate tissue oxygenation by correcting dehydration, maintaining fluid, electrolyte balance and adequate intravascular volume [18].

Crystalloids having almost similar composition of plasma are RL and SF. SF is a balanced isotonic solution for intravenous infusion with electrolyte composition very similar to plasma (Na-140, k- 4.0, Ca - 2.5, Mg - 1, and Cl – 127 mmol/l). It also has a potential base excess of zero and contains acetate (24 mmol/l) and maleate (5mmol/l) which is widely metabolized in all organs and muscles, resulting in low oxygen consumption which is 1.2L oxygen per liter solution [19-20].

RL contains sodium (130 mmol/L), potassium (5 mmol/L), calcium and magnesium (both at 1 mmol/l), chloride (112 mmol/L), and lactate (27 mmol/L). Its osmolarity is 276 mOsm/L which makes it slightly hypo osmotic when compared to plasma. Its base excess is 3mmol/l, and oxygen consumption is slightly higher than that of SF at 1.8L oxygen per liter solution. The lactate in RL was added to reduce the chloride content; thereby reducing the incidence of hyperchloremic metabolic acidosis which usually occurs after infusion of large volumes of normal saline during the intraoperative period [19-20]. Abnormalities of lactate metabolism are very common in patients undergoing prolonged surgery. The metabolism of lactate is dependent on the kidney and liver, and as such, when the functions of these organs are compromised, there will be lactate accumulation as well as reduction in production of bicarbonate resulting in lactic acidosis [21].

Nakayama *et al.* [22]. used acetated Ringer (SF) and RL solutions as an intraoperative fluid during hepatectomy and evaluated their effects on intraoperative and postoperative hemodynamics, metabolism, blood gas, and renal as well as liver functions. In contrast, Isosu *et al.* [23] used acetated ringer solution (AR) in his study to find its usefulness in patients with liver dysfunctionand compared with RL solution. L-lactic acid increased significantly in both groups.

Conclusion

Lactate levels were reducedin comparison with RL in patients undergoing free flap reconstructive surgeries due to use of acetate-based intravenous solutions. The results of our study suggested that the sterofundin is the better volume replacement solution in the initial treatment of postoperative and truama patient. Use of sterofundin in these patients was associated with low levels of serum lactate in comparison with Ringer's Lactate. Hence we conclude that the intraoperative use of Sterofundin is comparable or even better than Ringer's Lactate in terms of preservation of acid-base and electrolyte balance, avoidance of hypo/hyperglycaemia and cardiovascular stability in patients undergoing moderate to major surgery.

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