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New fluid therapy protocol in acute burn from a tertiary burn care centre

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ABSTRACT

Background: Ringer lactate is the main fluid for resuscitation of acute burns. However it is not a complete fluid alone, as it does not take care of sugar and electrolyte balance adequately. This study has been carried out to compare the use of Ringer lactate (RL) alone and combination of RL with Dextrose Normal Saline (DNS) as fluid replacement therapy in acute burn.
Objective: To assess the biochemical parameters with the use of DNS as maintenance fluid in combination with Ringer lactate as resuscitation fluid in acute burns resuscitation.
Method: A prospective randomized control study has been carried out by enrolling 200 patients into 2 groups, treated in ICU and resuscitated by using Modification of Brooke's formula (2 mL/kg/% TBSA for resuscitation plus 2500 mL maintenance). Group A received RL for resuscitation and DNS as maintenance in 1st 72 h of burns. Group B received RL only for 1st 72 h. The effects of this on various blood parameters were studied.
Results: Mean value of sodium at 24 h was 137.79 ± 3.89 in group A and was 133.2 ± 4.57 ($p < .0001$) in group B. The sodium levels remained in range of 137–138 ($p < .0001$) in group A with only 22% patients showing lower range of sodium levels, whereas, there was a falling trend ($p < .0001$) of sodium levels in group B on subsequent days with 54.00% ($p < .0001$) showing hyponatremia on 1st day which increased to 76% on 3rd day. Mean values of early morning random blood sugar (RBS) levels in group A remained between 165.5 ± 65.51 mg/dL–115.82 ± 32.52 mg/dL on all 3 days but in group B there was a falling trend from 127.49 ± 46.11 mg/dL to 102.84 ± 22.92 mg/dL by 3rd day. Thus, there was significant difference in levels of sodium and RBS in patients receiving DNS as maintenance fluid in addition to RL in acute phase.
Conclusion: RL is not an ideal fluid for maintenance as it is low in sodium (130 mEq/L) as well as potassium (4 mEq/L) in view of daily electrolyte requirement. There is no glucose content in it to provide calories. Therefore, DNS should be added as daily maintenance fluid with RL as replacement for evaporative losses following burns.
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1. Introduction

Proper fluid resuscitation of acute burns plays a very important role in its management since fluid loss in burned as well as in unburned tissue is the first physiological change that takes place following burns. A timely and appropriate fluid resuscitation after moderate to severe burns, especially in the golden period of first 72 h is therefore the single most important therapeutic intervention which reduces the early mortality following acute burns.

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Several formulae have been proposed during last century to substitute the circulating blood volume and thus prevent hypovolemic shock. Cope and Moore were first to suggest that resuscitation was based on body weight and extent of burn in 1947. Evans formula using crystalloids and colloids was first used in 1952 followed by modifications by Brookes and then Baxter and Parkland formula using only crystalloid as fluid for resuscitation. In all the regimes Ringer lactate (RL) remains the main resuscitation fluid for management of acute burns [1,2].

Modification of Brooke's formula was used in our unit for over 50 years wherein RL was used as replacement for lost fluid and 5% dextrose (5D) was used as maintenance therapy. However on closer observation it was found that some patients had hyponatremia and some patients had hyperglycemia on biochemical analysis as early as 24 h after burn. The possible reason for hyperglycemia was because 5D given for maintenance was adding to the stress hyperglycemia which follows trauma of acute burns.

Based on these observations we decided to base our study on comparing the use of RL vis a vis (Dextrose Normal Saline) DNS as maintenance fluid in a new regime of fluid protocol for acute burns. There is paucity of such study in the literature. Institute ethical committee clearance was obtained for this study.

2. Material and methods

This is a randomized prospective study conducted from January 2016 to December 2016 in a tertiary burn care centre of a developing country where the patient load is enormous. Our unit attends to over 5000 patients annually and admits over 1500 patients per year.

This study included 200 patients randomly divided into 2 groups. All thermal burns patients aged between 18–70 years and coming within 8 h of sustaining burns were included. Patients with co-morbid conditions, pregnancy and chemical burns were excluded. ICU care was provided for acute phase of burns.

We used Modification of Brooke's formula for calculating total amount of fluid. Maximum percentage was taken as 50%. In the 1st 24 h all patients received 2 mL/kg/% of burns Ringer lactate (RL) plus maintenance fluid calculated @ 50 mL/kg body weight. In the next 48 h fluid was given at the rate of 1 mL/kg/% of burns Ringer lactate (RL) plus maintenance fluid @ 50 mL/kg body weight. Group A received Dextrose Normal Saline (DNS) as maintenance fluid in 1st 72 h with RL as replacement fluid and group B received Ringer lactate for replacement as well as maintenance fluid both. Rest of the treatment protocol remained same in both the groups.

This tertiary care burn centre has well laid down protocol regarding fluid therapy in acute burn. The variation in the quantity of fluid is based on the urine output. This monitoring is done by the resident and well trained burn care nursing personnel under the supervision of consultant burn and plastic surgeon. These care givers were blinded to this study. Hence uniformity in the management is assured. All the patients were treated with closed dressing using silver sulphadiazine cream.

Adequacy of fluid was judged by hourly urine output which was maintained at .5 mL to 1 mL/kg/h. Serum sodium, potassium, blood sugar; urea and creatinine were studied at the end of 1st, 2nd and 3rd days after burn. Normal reference values were taken as; sodium: 135–145 mEq/L, potassium: 3.5–4.5 mEq/L, random blood sugar (RBS): 110–140 mg/dL, creatinine: less than .5–1 mg/dL and urea: 5–40 mg/dL.

The quantitative variables were compared using unpaired t-test/Mann–Whitney Test between the two groups and paired T test/Wilcoxon ranked sum test within the group across follow up. A p value of $<.05$ was considered statistically significant.

3. Results

Demographic details of patients in two groups are given in Table 1. Two groups were comparable in age and weight. Mean values of electrolytes and other parameters during first 72 h in two groups are given in Table 2.

During first, second and third 24 h lower sodium levels as per the laboratory normal values were found in 22.00%, 24% and 31% in DNS group and while it was 54.00%, 74% and 76% ($p<.0001$) in RL group (Graphs 1 and 2 and Table 4).

RBS levels <110 mg/L on 1st day was recorded in 34% patients in RL group which increased to 72% on 3rd day (p value—.0009) and in DNS group 13% patients had blood sugar levels <110 mg/L on 1st day and 48% (p value—.0009) by 3rd day. This indicates that the hypoglycemia occurs in relatively larger number of subjects in RL group as compare to DNS group and increases in subsequent days (Tables 2 and 3). Hyperglycemia (>200 mg/dL) which was seen in 29% on 1st day decreased to 2% by the end of 72 h in DNS group where as in RL group hyperglycemia was seen as 3% at the end of 24 h and by the end of third day no patient had recorded hyperglycemia (Table 3). Also the mean values of RBS were higher in DNS group than RL group (Table 2 and Graph 3).

Mean values of potassium, urea and creatinine and urine output were comparable in both groups (Table 3).

4. Discussion

In our study we were using Ringer lactate as replacement fluid and supplementing dextrose 5% for maintenance for over half a century. In an unpublished pilot study on our patients with this fluid regime, we discovered that some patients were hyponatremic and some patients were showing hyperglycemia. Normal saline was not preferred to correct the hyponatremia because of the risk of hyperchloremic metabolic

Table 1 – Demographic distribution in Group A and Group B.

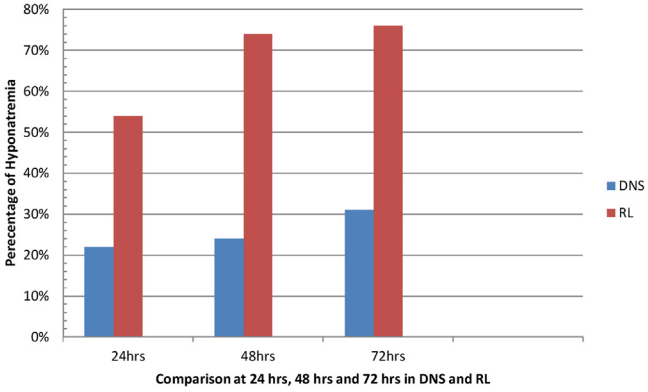
	Group A	Group B
Males (years)	29	39
Females (years)	71	61
Weight (kilograms)	58.94 ± 10.45	59.84 ± 11.44
Percentage of burns	46.28 ± 15.03	47.45 ± 12.86

p Value >.005.

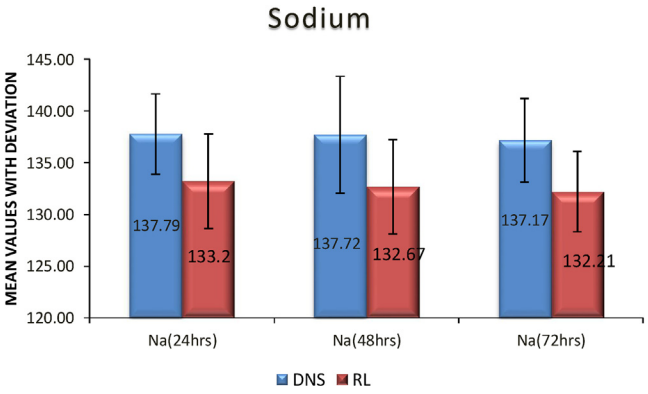
Table 2 – Mean values of RBS, sodium, potassium, urea, creatinine and urine output at 24h, 48h and 72h in Group A and Group B.

	24h			48h			72h		
	Group A	Group B	p Value	Group A	Group B	p Value	Group A	Group B	p Value
Sodium mEq/L	137.79	133.2	**<.0001**	137.72	132.67	**<.0001**	137.17	132.21	**<.0001**
RBS mg/dL	165.5	127.49	**<.0001**	132.5	111.93	**<.0001**	115.82	102.84	**<.003**
Potassium mEq/L	4.82	4.66	.065	4.46	4.38	.327	4.18	4.07	.207
Urea mg/dL	40.51	41.26	.222	36.14	38.74	.222	30.64	29.12	.255
Creatinine mg/dL	1.09	1.21	.412	1.03	.92	.230	.78	.78	.979
Urine output mL/h	99.49	106.54		59.84	64.98		66.44	68.44	.453

p Value <.05 is considered significant.
The bold values indicate significant p values.



Graph 1 – Percentage hyponatremia comparison at 24h, 48h and 72h in Group A and Group B.



Graph 2 – Comparison of sodium at 24h, 48h and72h in Group A and Group B.

acidosis [3] which is due to a rise in chloride relative to sodium. It was not providing the recommended calories either.

Hyponatraemia (Na) (<135 mEq/L) following burns is due to extracellular sodium depletion following changes in cellular permeability [4]. The extent of this process can be minimized by early restoration of perfusion. Failure to achieve this can cause widespread organ dysfunction [5]. Therefore, restoration of sodium losses in the burn tissue is essential.

Lowered levels of sodium can cause wide spectrum of symptoms starting from cramps, weakness, anorexia, nausea and vomiting. These symptoms were encountered in many of our patients which were often attributed to burn injury. This also led to delayed mobilization of patients adding to pulmonary complications. If not treated on time hyponateremia can progress, leading to neurological symptoms which are altered consciousness, seizures and cerebral oedema and cardiovascular symptoms causing low BP, low cardiac output leading to low GFR. This all end up in increased morbidity and mortality in burns.

Ringer lactate is isotonic crystalloid, close to plasma pH and combating metabolic acidosis [6] but did not seem to be a

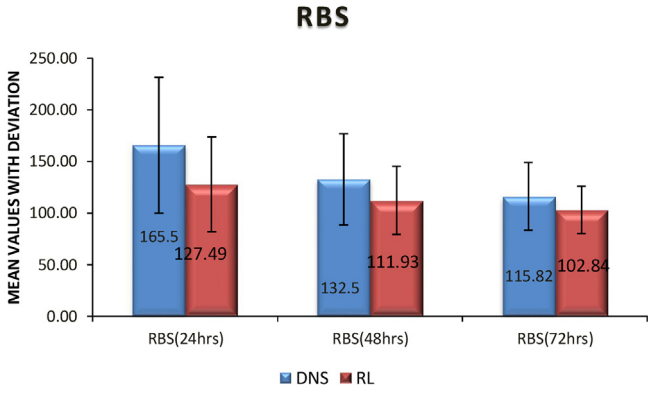
Table 3 – RBS levels distribution in Group A and Group B.

RBS (mg/dL)	24h			48h			72h		
	Group A	Group B	p Value	Group A	Group B	p Value	Group A	Group B	p Value
<110	13	34	**.0009**	29	1	**.0024**	48	72	**.0009**
110–130	21	29	.253	29	30	1	25	19	.393
131–150	17	22	.475	21	12	.127	11	4	.107
151–180	14	9	.375	13	6	.148	10	5	.283
181–200	6	3	.495	1	1	.477	4	0	.130
>200	29	3	<**.0001**	7	0	.021	2	0	.477

p Value <.05 is considered significant.
The bold values indicate significant p values.

Table 4 – Sodium levels distribution in Group A and Group B.

Sodium levels	Na at the end of 24h		Na at the end of 48h		Na at the end of 72h	
	Group A	Group B	Group A	Group B	Group A	Group B
115–120 mEq/L	0	1	0	0	0	0
121–124 mEq/L	0	5	1	3	0	2
125–130 mEq/L	6	26	6	29	1	33
131–134mEq/L	13	23	14	41	27	42
135–140 mEq/L	65	41	57	21	51	22
141–145 mEq/L	12	4	19	6	18	1
146–149 mEq/L	4	0	3	0	3	0



Graph 3 – Comparison of RBS at 24h, 48h and72h in Group A and Group B.

complete answer as its sodium, chloride and potassium levels are lower than extracellular fluid (130mEq/L,109mEq/L and 4mEq/L respectively). It also lacks in providing calories for a patient who is exclusively on intravenous therapy. Instead it contains lactate which gets converted to bicarbonate which on long term use can lead to alkalosis.

Changes in parameters which are seen on 1st few days of acute burns have a long term effect. As correction of sodium is delayed by initial low levels of sodium and catabolic process also starts soon after trauma, we needed a better quality fluid to prevent this process.

This inspired us to add another fluid i.e Dextrose Normal Saline (DNS) instead of 5% dextrose for maintenance with the RL as D5W provides calories but does not correct hyponatremia associated with burns. DNS on the other hand has higher levels of sodium (154mEq/L), chloride (154mEq/L) and glucose (50g/L). So besides replacing sodium it provides calories also. Even though DNS is labeled as hypertonic, it becomes isotonic when

administered in vivo, as it is immediately metabolized in the body. This new formula needed a large platform to be studied in order to prove it as a better quality fluid in terms of electrolytes and calories, hence the reason for this study.

It was observed that group A maintained sodium levels on all 3 days with little variation from day 1 to day 3 (Table 2) which indicates that combination of these two fluids is maintaining serum electrolytes in the already decompensated burned patient. As seen in Table 4, patients showing hyponatremia (<135 mEq/L) increases in Group A from 22% to 31% and in group B from 54% to 76% by the end of 3rd day. However, in Group A the levels of sodium (131–134 mEq/L) are below normal range of sodium but without any clinical symptoms vis a vis in Group B the sodium levels has fallen in range of 125–130 mEq/L and this hyponatremia is highly significant resulting in clinical symptoms. Patients showing symptoms of hyponatremia and levels <124 mEq/L were offered correction by sodium supplementation.

Comparison of RBS values in both groups at 24 h, 48 and 72 h was statistically significant ($p < .0001$ on all 3 days) with higher levels of RBS seen in DNS group. However, it did not require correction by insulin as by 3rd day average values did not exceed 200 mg/dL (Graph 3 and Table 3).

The hyperglycemia seen at the end of 24 h in 29 patients in group A was attributed to the effect of fluid therapy and stress hyperglycemia. So, no hyperglycemic control measures were given. In follow up observation it was noticed that almost all the patients showed gradually reduced RBS levels at the end of 72 h indicating that hyperglycemia control measures were not warranted.

Hyperglycemia is a common metabolic alteration in any critical patient relates to multiple factors but at the same time hypoglycemia proves to be a life threatening complication [7]. Initially it was thought that tight glycemic control i.e 72–106 mg/dl reduces mortality in ICU surgical patients [8] and this concept was extended for burn patients [9]. However, studies by various authors [10,11] confirmed that tight glucose control resulted in higher mortality rates than the more moderate target (i.e. <8 or <10 mmol/L) (145–180 mg/dL) [7]. It is desirable for the treatment of critically ill, septic or burns patients as burn patients are found to be having higher episodes of hypoglycemia attributed to special nature of injury triggering cascade of catabolic events [12].

To avoid complications arising from hypoglycemia, Jeschke suggested blood glucose levels of 130 mg/dL to be an ideal target [13] whereas other studies support levels of 130–150 mg/dL [14] because at this range protein glycolysation is avoided as well as an increased incidence of hypoglycemia [13]. Finfer et al. suggested that blood glucose target ≤180 mg/dL resulted in lower mortality than did a target of 81–108 mg/dL [15]. Dellinger et al. observed complications of hypoglycemic episodes, and their recommendation changed from maintaining glucose levels <150 mg/dL [16] to <180 mg/dL [17]. In addition, burn patients cannot be expected to have adequate tight glycemic ranges because of feeding interruptions and variability in gastrointestinal tolerance [12]. Owing to the requirement for frequent dressing changes, enteral nutrition needs to be stopped occasionally-further disrupting the gastrointestinal motility, and complicating adjustments [14].

In our study DNS group patients maintained the desired glucose levels, had lesser incidence of hypoglycemia thus avoiding downfall of tight glycemic control on the other hand in RL group percentage of patients with glucose <110 mg/dL increased from 1st day to 3rd day of burns.

When patients are on IV fluids we need to provide maintenance calories for first few days until patient is started on enteral or parenteral feeds. This requirement as measured for an average 50 kg adult is 125 g. 2500 mL DNS in our formula is providing 125 g of glucose per day. Carbohydrate in the form of dextrose aids in minimizing liver glycogen depletion and exerts a protein-sparing action. These calories (500 calories) can prevent protein breakdown which takes place in acute phase of stress and approximately 50–100 g/day of glucose limit starvation ketosis [18]. These calories are not substitute for energy requirement but will supplement daily calories requirement till patient starts accepting orally.

The amount of fluid given as per this modification of Brooke's formula was adequate in both groups as monitored by hourly urine output. Hence using these two types of fluids (DNS and RL) was not only economical but also medically and scientifically better.

5. Conclusion

The present study validates our formula in terms of quantity and quality (electrolytes and calories). Sodium and glucose levels are maintained better in DNS group than RL group on all 3 days. RBS levels which were seen higher than normal in DNS group came to within permissible limits by 72 h and they avoid risk of hypoglycemia which is associated with increased mortality. DNS as maintenance fluid also provided adequate calories during early phase of resuscitation. This new formula provides adequate amount of fluid as measured by adequate hourly urine output in both the groups. We recommend that DNS should be added as maintenance fluid in combination with RL, which is for evaporative losses rather than giving RL alone as in other formulae.

Conflict of interest

The authors declare that they have no conflict of interest.

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