

Original Research Article

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A clinical study on dyselectrolytemia and changes in renal function in patients with 25% to 60% flame burn injury

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ABSTRACT

Background: Severe fluid loss is the greatest problem faced following major thermal burn injuries accompanied by changes in the level of electrolytes. Standard fluid resuscitation derived from Parkland's formula and body's response to it is measured in terms of correction of dyselectrolytemia and urine output.

Methods: A prospective cross sectional study involving 80 patients were included in the study with male patients being 28 and females being 52. Flame burns involving $\geq 25\% - \leq 60\%$ of BSA presenting within 24 hours of flame burn injury were taken into account. Serial follow up of serum electrolytes was done on the day of presentation, day 2, day 3 and day 7 its effect on standard fluid resuscitation was studied.

Results: Renal function is indirectly related to the percentage of flame burn, hence decreasing urine output and linear increase in serum creatinine is suggestive of increased surface area of burn. The mean serum sodium on the day of admission was roughly normal whereas as the days progressed there was significant hyponatremia with normalisation of day 7, whereas serum potassium was initially normal followed by hyperkalemia.

Conclusions: An initial assessment involved calculation of percentage of total body surface area burn injury followed by of estimation of fluid requirement according to standard Parkland formula. Monitoring of electrolyte imbalance was noted for 2nd, 3rd and 7th day of hospitalisation. Derangements in these parameters were observed during course of admission followed by normalisation on the 7th day.

Keywords: Acute kidney injury, Dyselectrolytemia, Flame burn

INTRODUCTION

It is a widely accepted fact that severe fluid loss is the greatest problem faced following major thermal burn injuries accompanied by changes in the level of electrolytes. Hence, knowing the levels of these electrolytes and appropriate fluid management remains the cornerstone of modern burn treatment and lets us know how the body is responding to different therapies being provided.

A thermal burn patient has a number of complex injuries that must be taken care of. The initial post burn phase is characterized by cardiopulmonary instability ensued by electrolyte imbalance and significant shift of fluids

between compartments which needs to be taken care of primarily among other metabolic disturbances.¹ With the onset of wound inflammation, immunosuppression, and infection the physiological and metabolic parameters change from those seen initially. Therapeutics must therefore be based on knowledge of these changes in course of time. It is important to realize that many of the problems are predictable and should be prevented before they happen.

At present, fluid resuscitation formula which were developed several years ago has been accepted as guidelines, but ongoing studies focuses on growing concerns that burn patients are being over and under fluid resuscitated with indistinct and inappropriate end point targets.

In accordance with data of the literature, the incidence of hypophosphotemia, hypoproteinemia and hypocalcemia were correlated with the importance of the body surface area of burn. An elevation of potassium in the resuscitative phase and consequent decrease after resuscitation and a decrease of sodium have been observed. Standard fluid resuscitation is followed which is derived from Parkland's formula and body's response to fluid management is correlated in terms of correction of dyselectrolytemia and urine output.

The objective of the present research study was to evaluate the level of electrolytes on presentation of patient and on day 2, day 3 and day 7 and to study the effect of standard fluid resuscitation over it.

METHODS

Study setting

The present study was carried out in the department of surgery, SMCH using clinical samples from admitted flame burn patients in burn unit and patients attending surgery OPD and casualty. Samples were sent to department of biochemistry and central composite laboratory (CCL) at Silchar Medical College and hospital for serum electrolyte estimation, pathological, hematological and biochemical analysis.

Study design

The present study was a prospective cross sectional study.

Methods

A prospective cross sectional study was performed at Silchar medical college and hospital in burn ward. The clinical specimen (blood) was collected from each patient after obtaining approval from institutional ethics committee. Informed consent was obtained before specimen collection.

The blood samples which were withdrawn at the time of presentation to the casualty/burn ward, was sent to central composite laboratory for several pathological, hematological and biochemical estimation within two hours of collection.

Serial follow up of serum electrolytes was done on the day of presentation, day 2, day 3 and day 7 its effect on standard fluid resuscitation was studied.

Documentation of patients including identification, history, clinical findings, diagnostic tests were all recorded on a proforma specially prepared. Demographic data such as age, sex, occupation, nature and time of flame burn injury, time of presentation were documented during the course of study.

Study population

Inclusion criteria

Patients falling in age group of 15-60 years of both gender, patients presenting within 24 hours of flame burn injury, flame burns involving $\geq 25\% - \leq 60\%$ of BSA.

Exclusion criteria

Patients with scald burn, electrocution, cold, chemical burns etc. Facial and inhalational flame burn injury

Sample size

80 (N). The sample size was calculated by applying the following formula:

$$N = \frac{Z^2 pq}{L^2}$$

$$N = \frac{1.96 \times 1.96 \times 82.7 \times 17.2}{68.39}$$

$$N = 5464.45/68.39$$

$$N = 80 (N)$$

Where,

Z = Confidence level at 90% (standard value of 1.96)

p = Estimated prevalence

$$q = 1 - p$$

$$L = [(p \times 10) \div 100] \times 2$$

Where confidence level was 95% and power was 90%.

Scheme of case taking

80 number of patients above 15 years of age with more than 25% and less than 60% flame burn injury; irrespective of gender admitted in burn unit of SMCH were taken into consideration. Detailed history including the presence of co-morbidities was taken. The mode of burn injury, other comorbid condition like diabetes, hypertension, findings of clinical examination were recorded in the proforma for individual patients. Investigations like complete blood count, random blood sugar, kidney function tests, electrolytes were mandatory in all patients. Monitoring of urine output in patients in response to standard fluid resuscitation was noted mandatorily.

All the patients were diagnosed and managed according to standard protocol using Parkland's formula.

For all patients standard aseptic precaution were followed and blood was drawn for several pathological and biochemical analysis. All these were repeated again on day 2, 3 and 7th of admission.

Dyselectrolytemia was closely monitored and its response to standard fluid resuscitation was duly noted. Patient's response to adequate fluid resuscitation was evaluated in terms of urine output at regular intervals.

Follow up

The patients were followed up on day 2nd, 3rd and day 7th to correct the electrolyte imbalance and monitor adequate hydration.

On the 3rd and 7th day if electrolyte imbalance was seen then respective maintenance fluid was given to correct it. Renal function in terms of serum urea and serum creatinine with urine output was closely monitored.

Each case was analysed and tabulated. The following factors were taken into account: gender of individual, percentage of flame burn, standard fluid resuscitated (at the end of 1st 8 hours, end of next 16 hours and maintenance fluid), Hb, TLC, LFT (serum albumin and serum globulin on day 0, 2nd, 3rd and 7th), RFT (serum urea, serum creatinine, serum Na, serum K on day 0, 2nd, 3rd and 7th), urine output (1st 8 hours, next 16 hours, next 24 hours).

RESULTS

Age distribution

Total number of male patients were 28 and female patients were 52. The percentage of average burn was 39% in the age group of 15-30 years and 30-45 years in males whereas in females the average burn percentage was significantly high (44.3%). Percentage of flame burn in females was more in any age group when compared to males.

Table 1: Age distribution.

Age group	Average percentage burn in males	Average percentage burn in females
15-30	39	39.61
30-45	39	42.1
45-60	36.87	44.28

Average fluid provided to patients based on percentage burn (in the first 24 hours)

The amount of fluid needed for resuscitation was 14.38 liters in a percentage burn of 45%-50% in males and was 14.01 liters in females for the same percentage burn. The average amount of fluid resuscitated in the first 24 hours of admission was in increasing order in correspondence

to the burn percentage. The average amount of fluid resuscitated during the first 24 hours for given percentage of flame burn was more in males when compared to females because of increased weight.

Table 2: Average fluid provided to patients based on percentage burn (in the first 24 hours).

Burn percentage ^A	Average fluid provided in males (ml)	Average fluid provided in females (ml)
30	9528.8	8558.4
35	12012	9604
40	12240	11342.5
45	13746.6	13302.2
50	14375	14011.7

*A- The higher range of burn percentage is taken into account

Fluid versus urine output

The average fluid administered was in increasing order of burn percentage. The average urine output over the first 48 hours was in decreasing order of fluid resuscitated which in turn reflects increasing surface area of burn.

Table 3: Fluid versus urine output.

Fluid administered range (ml)	Average urine output in males (ml)	Average urine output in females (ml)	Total average urine output (ml)
6000-9000	1960	1662.2	1863.07
9000-12000	1973.6	2061	2067.09
12000-15000	1768	1932.3	1849.6
15000-18000	1580	2126.6	1926.6

In males, maximum urine output was 1.97 liters when fluid given was in range of 9-12 liters in comparison to decreased urine output when percentage burn was increased.

In females, maximum urine output was 2.13 liters when fluid administered was in range of 15-18 liters.

Changes in sodium

There was hyponatremia with on day 2 and day 3 of admission followed by normalization on day 7 on admission. On comparing sodium disturbance for day 0 and day 2 the p value was 0.000022 which was significant suggesting hyponatremia on day 2 of admission.

On comparison of sodium values for day 3 and day 7 the p value was 0.0000013 which is significant suggesting hyponatremia on day 3 followed by normalization on day 7 of admission.

Table 4: Changes in sodium.

Burn percentage ^A	Average Sodium (day 0)	Average sodium (day 2)	P value day 0 versus day 2	Average sodium (day 3)	Average sodium (day 7)	P value day 3 versus day 7
30	136.8	129.1		123.2	139.7	
35	137.0	125.9		121.2	137.0	
40	137.8	126.6	0.000022	121.8	135.5	0.0000013
45	137.6	127.8		123.6	137.1	
50	137.1	125.9		119.2	132.7	

*A- The higher range of burn percentage is taken into account

Table 5: Changes in potassium.

Burn percentage ^A	Average potassium (day 0)	Average potassium (day 2)	P value day 0 versus day 2	Average potassium (day 3)	Average potassium (day 7)	P value day 3 versus day 7
30	4.5	5.3		5.6	3.9	
35	4.2	5.3		5.6	4.3	
40	4.5	5.3	0.006	5.7	4.0	0.02
45	4.4	5.3		5.9	4.2	
50	4.3	5.4		5.9	4.3	

*A- The higher range of burn percentage is taken into account

Table 6: Changes in calcium.

Burn percentage ^A	Average calcium (day 0)	Average calcium (day 2)	P value day 0 versus day 2	Average calcium (day 3)	Average calcium (day 7)	P value day 3 versus day 7
30	6.9	6.4		6.1	6.8	
35	6.8	6.5		6.4	6.6	
40	6.9	6.2	0.003	6.0	6.7	0.638
45	6.8	6.0		5.6	6.9	
50	6.7	6.1		5.6	6.5	

*A- The higher range of burn percentage is taken into account

Changes in potassium

There was hyperkalemia with on day 2 and day 3 of admission followed by normalization on day 7 on admission. On comparing potassium disturbance for day 0 and day 2 the p value was 0.006 which was significant suggesting hyperkalemia on day 2 of admission.

On comparison of potassium values for day 3 and day 7 the p value was 0.020 which was significant suggesting hyperkalemia on day 3 followed by normalization on day 7 of admission.

Changes in calcium

There was hypocalcemia with on day 2 and day 3 of admission followed by normalization on day 7 on admission. On comparing calcium disturbance for day 0 and day 2 the p value was 0.003 which was significant suggesting hypocalcemia on day 2 of admission. There was normalization on day 7 of admission.

Changes in albumin

There was hypoalbuminemia on day 2 and day 3 of admission followed by normalization on day 7 on admission.

On comparing albumin disturbance for day 0 and day 2 the p value was 0.004×10^{-7} which was significant suggesting hypoalbuminemia on day 2 of admission.

On comparison of albumin values for day 3 and day 7 the p value was 0.001×10^{-23} which was significant suggesting hypoalbuminemia on day 3 followed by normalization on day 7 of admission.

Hypoalbuminemia was indirectly related to the percentage of burn.

Changes in hemoglobin

There was increase in Hb on day 2 and day 3 of admission because of hemoconcentration followed by normalization on day 7 on admission. On comparing Hb

value for day 0 and day 2 the p value was 0.0001 which was significant suggesting hemoconcentration on day 2 of admission.

On comparison of Hb values for day 3 and day 7 the p value was 0.011 which was significant suggesting hemoconcentration on day 3 followed by normalization on day 7 of admission.

Changes in creatinine

The amount of increase in creatinine was directly related to the percentage of burn.

There was increase in serum creatinine on day 2 and day 3 of admission. On comparing serum creatinine disturbance for day 0 and day 2 the p value was 0.0084 which was significant suggesting worsening renal function on day 2 of admission.

On comparison of serum creatinine values for day 3 and day 7 the p value was 0.00012 which was significant suggesting increased levels on day 3 when compared to day 7, in response to fluid resuscitation followed by normalization later.

Table 7: Changes in albumin.

Burn percentage ^A	Average albumin (day 0)	Average albumin (day 2)	P value day 0 versus day 2	Average albumin (day 3)	Average albumin (day 7)	P value day 3 versus day 7
30	3.3	2.6		3.4	4.0	
35	3.4	2.8		2.3	3.3	
40	3.5	3.0	0.004×10 ⁻⁷	2.4	3.6	0.001×10 ⁻²³
45	3.4	2.2		2.7	3.2	
50	3.4	2.2		2.6	3.1	

*A- The higher range of burn percentage is taken into account

Table 8: Changes in hemoglobin.

Burn percentage ^A	Average Hb (day 0)	Average Hb (day 2)	P value day 0 versus day 2	Average Hb (day 3)	Average Hb (day 7)	P value day 3 versus day 7
30	12.7	16.3		18.1	12.2	
35	12.4	17.0		17.2	12.4	
40	11.4	15.7	0.0001	17.9	11.2	0.011
45	12.7	15.3		18.0	11.2	
50	11.6	15.0		20.1	11.4	

*A- The higher range of burn percentage is taken into account

Table 9: Changes in creatinine.

Burn percentage ^A	Average creatinine (day 0)	Average creatinine (day 2)	P value day 0 versus day 2	Average creatinine (day 3)	Average creatinine (day 7)	P value day 3 versus day 7
30	0.81	2.12		2.54	0.66	
35	0.83	2.18		2.43	0.66	
40	0.82	2.09	0.0084	2.52	0.62	0.00012
45	0.73	2.15		2.42	0.56	
50	0.78	2.27		2.47	0.68	

*A- The higher range of burn percentage is taken into account

Table 10: Change in total leucocyte count.

Burn percentage ^A	Average TLC (day 0)	Average TLC (day 2)	P value day 0 versus day 2	Average TLC (day 3)	Average TLC (day 7)	P value day 3 versus day 7
30	8.4	13.5		16.7	12.2	
35	11.4	17.5		18.9	12.3	
40	10.6	16.2	0.4×10 ⁻¹¹	20.6	12.1	0.2×10 ⁻⁵
45	9.6	16.0		21.0	13.5	
50	10.4	19.0		23.5	13.6	

*A- The higher range of burn percentage is taken into account

Change in total leucocyte count

The increase in TLC was directly related to the percentage of burn. There was increase in TLC on day 2 and day 3 of admission followed by normalization on day 7 of admission. On comparing the TLC value for day 0 and day 2 the p value was 0.4×10^{-11} which was significant suggesting leukocytosis on day 2 of admission.

On comparison of TLC values for day 3 and day 7 the p value was 0.2×10^{-5} which was significant suggesting infection on day 3 followed by normalization on day 7 of admission.

DISCUSSION

The burn patients need very special care as they can have associated mechanical injuries, inhalational injury and altered physiology with the risk of hypothermia. Once the patient survives from the acute phase, the appropriate wound management is the further challenge. Thus focused approach of burn patients allows critical care support, early surgical excision and closure of the burn wounds, patient and family education, continuous long-term rehabilitation and reconstructive surgical needs.

Severe burn injury induce a capillary leak characterized by fluid dysregulation, electrolyte imbalance, loss of proteins and circulatory insufficiency. Fluid resuscitation within the first 24 hours after burn injury is monitored and its effect on several electrolyte values is of paramount importance while treating these patients.

Respiratory water losses, osmotic diuresis secondary to accentuated glucose intolerance, high protein feeding, and derangements in hormone mechanisms contribute to increased fluid losses despite an adequate urine output. The transdermal fluid loss after burn injury is terminated by complete reepithelialization or after skin grafting surgery.

The present study was carried out among 80 patients between 15-60 years of age with 25-60% flame burn injury irrespective of gender admitted in burn unit of Silchar Medical College and Hospital from 1st June 2019 to 31st May 2020. 80 patients with flame burn injury were closely monitored and changes in electrolytes in response to standard fluid resuscitation were evaluated on subsequent days of admission. Fluid resuscitation within the first 24 hours after burn injury is commonly monitored by measuring urinary output, haematocrit and mean arterial pressure.

Age

In our study the average youngest age in male patients was 36 years and in females was 39 years. The average age where most flame burn injury occurred in women fell in age group of 45-60 years. Sarbazi et al observed similar finding in their study.² They had reported 30.38

years of mean age in their study. In India men are more likely to be burned in the workplace and women at home, especially in the kitchen.³

Average fluid resuscitated to patients based on percentage burn

The average amount of fluid resuscitated was directly proportional to the percentage burn irrespective of gender being maximum in 45-50% flame burn injury. The fluid resuscitation in our study was guided by Parkland formula. Namder et al also observed similar findings in their study.⁴ Their findings showed, that there is a relevant transdermal fluid loss after severe burn injury which should be replaced for fluid maintenance until burn wound closure is achieved.

Urine output in response to fluid resuscitation

The average amount of fluid resuscitated was directly proportional to the percentage of flame burn. Renal function is indirectly related to the percentage of flame burn, hence decreasing urine output is suggestive of increased surface area of burn. In this study it was observed the average (48 hours) urine output was maximum i.e. 2 litres in percentage burn of 35-40% and decreased with increased order of burn.

Change in sodium

The mean serum sodium on the day of admission was roughly normal whereas as the days progressed there was significant hyponatremia with normalisation of day 7 of admission. According to Sen et al hyponatremia occurred in 6.8% of patients with over 42% of sodium measurements above or below the normal range.⁵ Disruption of sodium regulation reflects abnormalities in serum water content and circulating plasma volume. These changes can have profound effects on a patient's physiology resulting in increased morbidity and mortality.

Change in potassium

The mean serum potassium on the day of admission was roughly normal whereas subsequently there was hyperkalemia on day 2 and day 3 of admission followed by normalisation on day 7. In the study conducted by Navarrete et al showed similar findings as this study.⁶ They also cited the presence of hyperkalemia is related to severity of rhabdomyolysis or the extent of the burn; reflecting worsening renal function.

Change in calcium

In this study the change in serum calcium was initially normal on the day of admission followed by hypocalcemia and subsequently normalisation after a week of admission. This change was directly proportional to the degree of burn percentage.

Change in albumin

In our study, the disturbance in serum albumin is directly related to the percentage of burn. The average serum albumin was lowest i.e. 2.2 gm/dl in percentage burn of 40-45%; irrespective of gender. Our study showed progressive hypoalbuminemia on day 2 and day 3 of admission followed by near normalisation on day 7. Soedjana et al showed serum albumin reduction is highly associated with the increased mortality risk in major burn injuries as the inflammatory mediators induce vascular permeability that causes protein loss into the interstitial space, which results in intravascular fluid, electrolytes and protein depletion.⁷ The resulting inflammation in burn patients itself decreases albumin synthesis. This depletion in serum albumin is used for predicting complications in flame burn injury.

Change in haemoglobin

In our study there was progressive anaemia after the initial hemoconcentration phase and that there was a correlation between the degree of anaemia and burn severity due to accelerated destruction of RBC's. This disturbance in haemoglobin levels correlated to degree of burn injury. According to El-Sonbaty et al, severely burned patients became anaemic by day 4 post-burn, when blood transfusion had to be initiated in order to replace destroyed red blood cells and to improve tissue oxygenation.⁸

Change in creatinine

The serum creatinine value on the day of admission was normal in our study followed by linear increase on day 2 and day 3. The values came to normal on day 7 of admission. The change in serum creatinine is directly related to the kidney function with worsening seen on increasing percentage of total body surface burn which correlated with the study conducted by Ibrahim et al.⁹ Urine output is considered a good indicator for adequate resuscitation. Persistent low urine output with increasing serum creatinine indicates inadequate resuscitation or due to massive release of inflammatory mediators suggestive of acute kidney injury.

Change in TLC

In our study there was progressive leucocytosis which was observed on day 2 and 3 of admission. This correlated linearly to the amount of percentage burn and infection which developed on day 3 of hospitalisation. This showed similar findings to the study conducted by El-Sonbaty et al.¹⁰

Limitation of this study is that it doesn't deal with the post burn complications or follow up long enough to address the post burn contracture.

CONCLUSION

Patients with severe thermal burns are at significant risk of death and major morbidity. Proper management during their initial resuscitation reduces such risks.

The observation in our study reveals a primary trauma survey with adequate maintenance of airway, breathing and circulation. An initial assessment also involved calculation of percentage of total body surface area burn injury and depth followed by estimation of fluid requirement according to standard Parkland formula. Subsequent monitoring of perfusion in terms of measurement of urine output, blood pressure and serum creatinine was noted. Monitoring of electrolyte imbalance was noted for 2nd, 3rd and 7th day of hospitalization. Several physiological and biochemical parameters like urine output, serum sodium, serum potassium, serum creatinine, hemoglobin and total leucocyte count were incorporated in our study and its correlation on subsequent days of admission with respect to standard fluid resuscitation derived from Parkland's formula was studied. Derangements in these parameters were observed on 2nd and 3rd day of admission followed by normalization on the 7th day, irrespective of the gender of the patient.

Management of above along with adequate wound care, analgesics and physiotherapy remained the cornerstone in holistic care of any flame burn patient.

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