CHARACTERISTICS OF ELECTROLYTE DISTURBANCES AT ADMISSION AND RELATED FACTORS IN SEVERE BURN PATIENT

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SUMMARY

This study aimed to evaluate characteristics of electrolyte disturbances at admission and related factors in the severe burn patient. A retrospective study was carried out on 241 burn patients with burn extent > 20% of BSA, hospitalized at Vietnam National Burn Hospital for 2 years (2021 - 2022) with treatment duration > 3 days. The results showed that Electrolyte disturbances at hospital admission were mainly due to hyponatremia and hypocalcemia (51.04% and 35.27%).

There were 7.05% cases of hyperkalemia. Hyperkalemia in patients with burn extent ≥ 50% TBSA, deep burn area ≥ 20% TBSA was remarkably higher than in patients with burn area < 50% TBSA, deep burn area < 20% TBSA (p < 0.05). Hypocalcaemia was more common in electric burn patients than in other cases, the difference was statistically significant (p = 0.004). The electrical burn agent and deep burn area were independently related to hypocalcemia on admission. While the area of deep burns was independently related to potassium disturbances on admission.

Keywords: *Electrolyte disturbances, burns.*

1. OVERVIEW[1]

Burn shock often causes electrolyte disturbances in the patient's blood due to burn injury, which reduces cell membrane activities in both the burned and non-burned areas. The dysfunction of the Na-ATPase pump causes intracellular sodium stagnation, and extracellular sodium deficiency [1].

Rhabdomyolysis in deep burns, erythrocyte destruction and metabolic acidosis cause increased extracellular potassium [2], [3]. Electrolyte disturbances cause neuropsychiatric as well as cardiovascular disorders in burn shock patients. This study aimed to evaluate characteristics of electrolyte disturbances at admission and related factors in the severe burn patient.

2. SUBJECTS AND METHODS

A retrospective study was carried out

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on 241 burn patients with burn extent > 20% of BSA, hospitalized at Le Huu Trac National Burn Hospital for 2 years (2021 - 2022) with treatment duration > 3 days. The patient's electrolyte levels were determined immediately upon admission. Normal blood sodium concentration was 135 - 145mmol/l, with disorder when blood sodium concentration was < 135mmol/l or > 145mmol/l. Normal blood potassium concentration was 3.5 - 5mmol/l, with the disorder when blood sodium concentration was < 3.5mmol/l or > 5mmol/l. Normal blood ionized calcium concentration was 0.9 - 1.55mmol/l, with the disorder when blood sodium concentration was < 0.9mmol/l or > 1.55mmol/l.

3. STUDY RESULTS

Table I. Patient characteristics (n = 241)

Criteria	Value (n = 241)
Age, years, $\overline{X}$ ± SD (Min-Max)	39.9 ± 0.8 (18 - 60)
Male, n (%)	193 (80.1)
Admission time post burn (< 24h), n (%)	224 (92.9)
Electric burns, n (%)	51 (21.16)
Comorbidity, n (%)	9 (3.73)
Combined injury, n (%)	4 (1.66)
Burn extent, Median, %BSA	45 (34 - 62)
Deep burn area, Median, %BSA	13 (3 - 30)
Inhalation injury, n (%)	53 (22.0)
Mortality, n (%)	61 (25.3)

The studied patients were severe and very severe burns with a burning extent of 45 (34 - 62%) and a deep burn area of 13 (3 - 30%). There are 22% of patients with inhalation injuries. The mortality rate was 25.3%

Table II. Concentrations of electrolytes at hospitalization

Parameter	Increase	Decrease	Normal
Na^+ (n,%)	0	123 (51.04)	118 (48.96)
K^+ (n,%)	17 (7.05)	53 (21.99)	171 (70.95)
Ca^{2+} (n,%)	0	85 (35.27)	156 (64.73)

At hospitalization, the sodium concentration mainly decreased compared to the normal value (51.04%). There were 7.05% of patients with increased potassium concentration and 35.27% of patients with decreased calcium concentration. There were no cases of increased sodium and calcium levels at hospitalization.

Table III. Characteristics of electrolyte disorders according to subgroups

Criteria	Subgroup	Na[1] n (%)		K[2] n (%)			Ca[3] n (%)		$p_{1,2,3}$	$r_{1,2,3}$
		Normal	Decrease	Normal	Decrease	Increase	Normal	Decrease		
Gender	Male (n=107)	47 (43.93)	60 (56.07)	70 (65.42)	25 (23.36)	12 (11.21)	62 (57.94)	45 (42.06)	0.11 0.22 0.52	0.1 0.02 -0.04
	Female (n=23)	6 (26.09)	17 (73.91)	18 (78.26)	5 (21.74)	0 (0)	15 (65.22)	8 (34.78)		
Age group	18-40 (n=81)	31 (38.27)	50 (61.73)	57 (70.37)	18 (22.22)	6 (7.41)	51 (62.96)	30 (37.04)	0.46 0.59 0.27	0.01 0.04 -0.01
	> 40 (n=49)	22 (44.9)	27 (55.1)	31 (63.27)	12 (24.49)	6 (12.24)	26 (53.06)	23 (46.94)		
Admission time post burn, h	< 24	**2 (10)**	**18 (90)**	15 (75)	4 (20)	1 (5)	12 (60)	8 (40)	**0.002** 0.69 0.94	**-0.36** 0.06 0.07
	24-72	**51 (46.36)**	**59 (53.64)**	73 (66.36)	26 (23.64)	11 (10)	65 (59.09)	45 (40.77)		
Burn extent, %TBSA	< 50 (n=64)	26 (40.63)	38 (59.38)	**45 (70.31)**	**18 (28.13)**	**1 (1.56)**	36 (56.25)	28 (43.75)	0.98 **0.008** 0.5	0.02 **0.3** -0.1
	≥ 50 (n=66)	27 (40.91)	39 (59.09)	**43 (65.15)**	**12 (18.18)**	**11 (16.67)**	41 (61.12)	25 (37.88)		
Deep burn area, %TBSA	< 20% (n=78)	35 (44.87)	43 (55.13)	**58 (74.36)**	**17 (21.79)**	**3 (3.85)**	49 (62.82)	29 (37.18)	0.24 **0.02** 0.31	-0.08 **0.3** -0.2
	≥ 20% (n=52)	18 (34.62)	34 (65.38)	**30 (57.69)**	**13 (25)**	**9 (17.31)**	28 (53.85)	24 (46.15)		
Inhalation injury	No (n=98)	38 (38.78)	60 (61.22)	66 (67.35)	25 (25.51)	7 (7.14)	55 (56.12)	43 (43.88)	0.42 0.23 0.21	0.1 0.2 -0.01
	Yes (n=32)	15 (46.88)	17 (53.13)	22 (68.75)	5 (15.63)	5 (15.63)	22 (68.75)	10 (21.25)		
Electric burns	No (n=100)	40 (40)	60 (60)	68 (68)	20 (20)	12 (12)	**66 (66)**	**34 (34)**	0.75 0.07 **0.004**	-0.04 -0.12 **-0.2**
	Yes (n=30)	13 (43.33)	17 (56.67)	20 (66.67)	10 (33.33)	0 (0)	**11 (36.67)**	**19 (63.33)**		

Patients hospitalized within 24 hours of the burn had significantly more hyponatremia than those admitted 24 hours after the burn (90% vs 53.64%; p = 0.002).

Hyperkalemia in patients with burn extent ≥ 50% TBSA, deep burn area ≥ 20% TBSA was remarkably higher than in patients with burn area < 50% TBSA, deep burn area < 20% TBSA ($p < 0.05$). Hypocalcaemia was more common in electric burn patients than in other cases, the difference was statistically significant ($p = 0.004$). There was no difference in gender, age group, and inhalation injury in terms of electrolyte disturbances.

Blood sodium concentration at hospitalization was negatively related, moderately level with admission time post burn (p = 0,000). There was a positive, moderate relationship between burn extent, deep burn area and blood potassium concentration ($p < 0.001$). While, between electric burns, deep burn area and blood calcium concentration there is an inverse relationship, low level ($p < 0.01$).

Table IV. Multivariate analysis for electrolyte disturbances

Criteria	K^+		Ca^{2+}	
	Coef.	**p**	**Coef.**	**p**
Electric burns			-0.06 (-0.11 - (-0.02))	**0.009**
Burn extent	0.003 (-0.004 - 0.009)	0.42		
Deep burn area	0.007 (0.001 - 0.014)	**0.03**	-0.001 (-0.002 - (-0.0004))	**0.005**
Inhalation injury	-0.02 (-0.45 - 0.42)	0.22		
Ventilation	0.1 (-0.32 - 0.52)	0.65		
_cons.	3.65 (3.39 - 3.92)	0.000	0.97 (0.94 - 0.99)	**0.000**

Electrical burn agent and deep burn area were independently related to hypocalcemia at hospitalization. While the area of deep burns was independently related to potassium disturbances at hospitalization.

4. DISCUSSION

Fluid resuscitation was a mandatory treatment in the period of burn shock in severe burn patients to stabilize blood pressure, and tissue and tissue perfusion. Furthermore, large amounts of intravenous fluids are required in patients with extensive burns and great depth. However, when infusing a large amount of crystalloid into the lumen, accompanied by increased vascular permeability, a large amount of plasma was released into the intercellular space, which can cause extracellular fluid overload and electrolyte disturbances.

Reports around the world show that hyponatremia on admission ranges from 11% to 38.2% [4], [5], [6]. Our study results in Table 2 shows that 51.04% of hospitalized patients had hyponatremia, this rate was higher than previously reported in both burn and non-burn patients. This may be because we only enrolled patients with severe burns (≥2 0% of TBSA), which was different from other studies that included all burn patients in a hospital.

According to Ramos C.G. (2000), the electrolyte disturbances during initial resuscitation in burn shock patients (in the first 36h after burn) were characterized by hyponatremia and hyperkalemia, hyponatremia due to dysfunction of Na-ATPase pump causing intracellular sodium stagnation, extracellular sodium deficiency [1].

The extent of this process depends on the severity of shock and can be minimized by early restoration of perfusion in the injured tissues. Failure to achieve this can cause widespread organ dysfunction, such as neurological disorders (altered consciousness, seizures, cerebral edema, coma), gastrointestinal disorder (anorexia, nausea, vomiting), and neuromuscular disorder (cramps, weakness). This is also consistent with the results of our study (Table 3), blood sodium concentration at hospitalization was negatively related, moderately level with admission time post burn ($p = 0.000$). Hyponatremia usually occurs within 24 hours after the burn, so it is important to pay attention to correct it in time (table 3).

Hyperkalemia has been regarded as a complication in patients with burn injuries [7], as a result of extensive superficial tissue destruction [8], erythrocyte destruction [2], and metabolic acidosis [3]. Manifestations of hyperkalemia are more pronounced in acute hyperkalemia, and in particular, affect the cardiovascular system (cardiac changes depend on the rate of increase of potassium) [1].

The incidence of hyperkalemia in burn patients on admission varies in reports. In the Schaner et al. study, greater increases in serum K^+ were more frequent in patients with larger burns and the incidence of hyperkalemia was reported by 25.3% [9]. While the prevalence of hyperkalemia was only 1.2% in another study [10].

The results of our study show that 7.05% of patients have increased potassium levels on admission (table II). Hyperkalemia in patients with burn extent ≥ 50% TBSA, deep burn area ≥ 20% TBSA was remarkably higher than in patients with burn area < 50% TBSA, deep burn area < 20% TBSA ($p < 0.05$) (table III). When multivariate analysis showed that only the deep burn area was independently related to potassium disturbances on admission.

Hypocalcemia occurs as a result of the calcium shift between fluid compartments and increased urinary losses [1]. This is apparent after the first 48 h post-burn and is more prevalent on day 4, lasting until 7 weeks post-burn. Whenever possible, it is advised to monitor the ionized fraction, which represents about 45% of total circulating calcium, as it is independent of pH and albumin and therefore gives more accurate values [11].

The results of our study in Table 2 show that 35.27% of hospitalized patients had calcium levels lower than normal values. There were no cases of increased calcium levels on admission. The results of Table 5 when multivariate analysis showed that electric burn agent and deep burn area were independently related to hypocalcemia on admission. This tells us that when electric burns patients and/or with large areas of deep burns need to correct calcium disorders, avoid dangerous complications, and increase the severity of the patient's condition.

The limitation of this study is that there were patients who received fluid resuscitation at the frontline so electrolyte disturbances may not reflect the true extent.

5. CONCLUSION

The electrolyte disturbances on admission were mainly due to hyponatremia and hypocalcemia (51.04% and 35.27%). There were 7.05% cases of hyperkalemia. Electrical burn agent and deep burn area were independently related to hypocalcemia at hospitalization. While the area of deep burns was independently related to potassium disturbances at hospitalization.

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