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Prognosis of Patients with Severe Burns Based on Plasma Base Excess and Serum Lactate Level and Comparison with Absi

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ABSTRACT

Introduction: Burn injuries are among the most severe forms of trauma which cause many disabilities, complications, and mortality, along with high hospital costs and emotional problems. This study aimed at investigating the prognosis of patients with severe burns by measuring the plasma base excess (BE) and serum lactate levels and comparing them with the abbreviated burn severity index (ABSI) as an important indicator in the resuscitation of patients with burns.

Methods: This prospective cohort study was performed on all patients hospitalized in the burn ward of the hospital. The demographic characteristics and ABSI scoring of all patients were recorded. Patients' clinical information and routine tests, as well as gasometry (for measuring plasma BE) and serum lactate levels were also measured upon admission, 12 h, and 24 h after admission. The collected information was analyzed by SPSS software (version 24).

Results: This study evaluated 311 burn patients. Mann-Whitney test showed a significant difference between the patients who were discharged and those who died (P<0.001) in terms of mean plasma BE1 (upon admission) and BE2 (24 h after admission). The results also indicated a difference in the process of lactate changes between the two groups of patients in terms of the intensity of ABSI (P<0.001). The multivariate logistic regression with the entry of BE and lactate upon admission and ABSI as predictive variables indicated a significant BE (OR=0.88, 95% CI=0.92-0.8, P<0.001) and ABSI (OR=1.82, 95% CI =1.53-2.17, P<0.001).

Conclusion: According to the findings of this study, plasma BE can be used as an invaluable tool in the resuscitation monitoring of burn patients along with clinical criteria. On the other hand, the ABSI scoring system is still a beneficial tool to predict the mortality rates of burn patients.

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Introduction

In patients with burns greater than 20%, due to the activity of inflammatory mediators, a large volume of intravascular fluid enters the subcutaneous space, and as a result, the burn shock occurs. In these cases, to increase tissue blood supply, it is necessary to prescribe an appropriate amount of crystalloid fluid in proportion to the burn percentage in the first 24 h. Currently, in most medical centers, the adequacy of fluid therapy is assessed based on clinical symptoms (blood pressure, heart rate, and urine output), while in many cases of patients in the shock phase, in spite of

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normal clinical criteria, there is an increase in serum lactate or a decrease in the base excess (BE) (becoming more negative), which is an undeniable paraclinical reason for insufficient tissue blood supply (hidden hypotension) (1).

Tissue perfusion status in burns can be evaluated by measuring plasma BE and serum lactate, and this index with higher sensitivity and specificity, compared to clinical symptoms (blood pressure, heart rate, and urine output), helps the doctor for effective resuscitation of the patient. Total body surface area (TBSA) is the most important factor which is considered to predict the prognosis of burn patients in terms of systemic infection (sepsis), organ dysfunction syndrome, and death. A higher TBSA indicates a higher probability of complications and death. The TBSA in burns can be considered equivalent to the Injury Severity Score in trauma (2, 3).

In trauma patients, a decrease in the BE (becoming more negative) and an increase in the lactate level, thereby causing lactic acidosis, especially in the first 24 h after the injury, have been associated with increased mortality rate and length of hospitalization. In patients with major burns, tissue perfusion status can be evaluated by measuring the BE and serum lactate level, and studies have shown that these indicators have higher sensitivity and specificity than clinical assessment in evaluating the adequacy of resuscitation in these patients (4).

On the other hand, it has been determined that proper fluid resuscitation in the first 48 h of burns has a great effect in reducing the mortality of these patients. Therefore, the evaluation of the serum level of these markers (which indicates the recovery status of patients) can be a suitable predictive tool for the mortality and morbidity of patients with severe burns. On the other hand, many clinical indicators and scoring systems are used to determine the prognosis and mortality rates in severe burns (5).

The abbreviated burn severity index (ABSI) is one of the most acceptable and reliable of these indicators. The scoring system is based on five clinical criteria (age, gender, burn percentage, inhalation injury, and full-thickness skin burn), and the probability of patients' death is predicted based on this tool (6). ABSI is a fast, low-cost, reproducible, effective, and practical screening system for the classification of burn patients and is related to the total days of stay in the hospital and intensive care unit (ICU) (7).

A retrospective study evaluated the relationship between lactate and plasma BE with mortality in burn patients and showed that the plasma BE was significantly higher in the deceased patients than in the survivors (8). Furthermore, according to a study conducted by Cartoto, the value of plasma lactate as a marker of shock and resuscitation is higher than that of plasma BE (9). According to the mentioned study, the predictive power of plasma lactate is not limited to trauma patients and includes non-trauma patients admitted to the ICU. Accordingly, this study aimed at investigating the prognosis of patients with severe burns by measuring plasma BE and serum lactate level and comparing them with the ABSI scoring system.

Materials and Method

This prospective cohort study was performed on all patients with acute burns who were admitted to the male burn ward, female burn ward, and burn ICU within one year, regardless of age and gender. On the other hand, patients who had chronic burns (rehospitalization), infectious diseases, history of uncontrolled diabetes, as well as kidney and liver failures were excluded from the study.

Demographic and epidemiological characteristics of the patients were recorded on the first day of hospitalization based on the designed checklist, their ABSI was calculated, and the probability of mortality was predicted and recorded based on the American Burn Association Protocol. In addition to routine tests, gasometry (to measure plasma BE) and serum lactate level measurement were performed during hospitalization, 12 h later, and 24 h after hospitalization. Finally, the patients were followed up during hospitalization, and the final course of the patient was recorded as death or discharge. The collected information was entered into SPSS software (version 24), and data were statistically analyzed. The trend of lactate changes was investigated in three periods by ANOVA test with repeated measurements (or its non-parametric equivalent). In all calculations, $P<0.05$ was considered statistically significant.

Considering data confidentiality, patients' information was coded and entered anonymously. Moreover, the ethical principles of Helsinki were followed in this study. The study protocol was approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran (IR.MUM.MEDICAL.REC.1395.108).

Results

This study investigated 311 patients (61.1% male and 38.9% female) who were hospitalized with acute burns in the male burn ward, female burn ward, or burn ICU of the hospital. Mean±SD (median and range between quartiles) age of the patients (21.5 and 5.7-35.2) was obtained

at 24.7±20.7. Moreover, the mean±SD values of burn percentage (34 and 20-56) and ABSI (7 and 5-9.25) were determined at 39.4±24.6 and 7.63±3, respectively. Among the studied patients, 238 (76.5%) cases were finally discharged from the hospital and 73 (23.5%) patients died.

The most common type of burn (63.9%) was by fire, followed by burning with boiling water (31.5%). In addition, chemical burns (2.6%) and electrical burns (2.6%) were ranked third and fourth, respectively.

The mean plasma BE values upon admission were -12±7.3 and -4.3±4.8 in the deceased and discharged groups, respectively (P<0.001). Following that, the mean BE2 (24 h after hospitalization) values were -8.5±5.8 in the deceased group and -2.4±3.9 in the discharged group (P<0.001). In addition, BE changes were estimated at 3.0±6.6 and 1.9±4.8 in the deceased and discharged groups, respectively (P=0.13) (Figure 1). Upon admission, serum lactate levels were reported as 39.3±18.9 and 17.9±10.9 in the deceased and discharged groups, respectively (P<0.001). Moreover, serum lactate levels 12 h after admission were 30.6±13.8 in the deceased group and 12.2±7.3 in the discharged group (P<0.001). Additionally, 24 h after admission, the serum lactate levels were determined at 31.7±13.3 and 13.1±9.5 in the deceased and discharged groups, respectively (P<0.001).

The changes in lactate level were obtained at -8.7±11.8 and -5.8±7.9 in the deceased and discharged groups between the two-time intervals of admission and 12 h after admission, respectively. Mann-Whitney test considering Bonferroni's correction indicated that the changes were statistically significant (P=0.012) (Table 1). ANOVA test with repeated measurements showed a significant difference between the deceased and discharged groups regarding the lactate changes (P<0.001) (Figure 2).

The median of ABSI in the studied sample was considered the cut-off limit. Mann-Whitney test was used to compare the mean of BE1 (upon admission) in the ABSI≥7 group (-8.1±6.8) with the ABSI≤6 group (-3.5±4.6) and indicated a significant difference between the two groups (P<0.001). Furthermore, the Mann-Whitney test compared the mean of BE2 (24 h) in the ABSI≥7 group (-4.8±5.9) with the ABSI≤6 group (-2.4±3.4) and indicated a significant difference between the two groups (P<0.001). Moreover, according to the results of the Mann-Whitney test, BE changes in the two investigated periods were significantly higher in the ABSI≥7 group (3.1±5.7), compared to the ABSI≤6 group (1±4.4) (P<0.001) (Figure 3).

Mann-Whitney test also showed that lactate level upon admission was significantly higher in the ABSI≥7 group (29.8±17) than in the ABSI≤6 group (13.7±8.3) (P<0.001). Furthermore, the results revealed that 12-hour lactate was significantly higher in the ABSI≥7 group (21.5±13.3), compared to the ABSI≤6 group (9.8±5.3) (P<0.001). In addition, 24-hour lactate was significantly higher in the ABSI≥7 group (23.3±14.8) than in the ABSI≤6 group (9.1±2.3) (P<0.001).

Mann-Whitney test considering Bonferroni's correction showed that lactate changes upon admission and 12 h later was higher in the ABSI≥7 group (-8.4±10.2), compared to the ABSI≤6 group (-3.8±6.3) (P<0.001) (Table 2). It is worth mentioning that other changes were not statistically significant.

Repeated measurements ANOVA revealed a difference in lactate changes between the two groups of patients in terms of ABSI severity

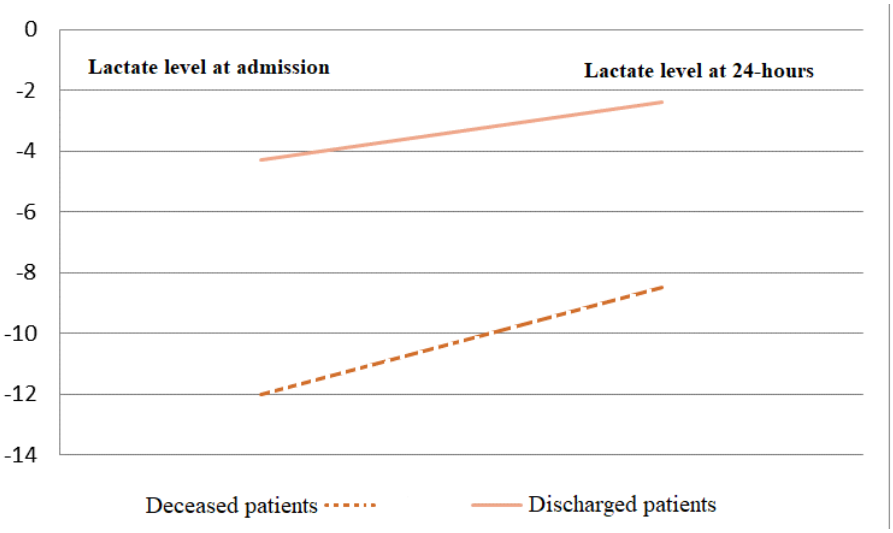

Figure 1: Mean plasma base excess in two groups

Table 1: Changes in serum lactate levels in the studied patients

Time	Discharged patients	Deceased patients	P value
0-12 h	-5.8±7.9	-8.7±11.8	0.012
0-24 h	-9.8±9.2	-11.1±12.7	0.56
12-24 h	-2.5±4.7	-2.4±9.3	0.49

(P<0.001) (Figure 4). Univariate logistic regression analysis was used to examine BE upon admission (P<0.001, 95% CI=0.75-0.85, OR=0.79), lactate upon admission (P<0.001, 95% CI=1.07-1.12, OR=1.09), and ABSI (P<0.001, 95% CI=1.69-2.31, OR=1.98). Multivariable logistic regression analysis with the entry of BE and lactate upon admission, and ABSI, as predictor variables, indicates the significance of BE (P<0.001, 95% CI=0.82-0.94, OR=0.88) and ABSI (P<0.001, 95% CI=1.53-2.17, OR=1.82).

Discussion

Severe burns cause serious and unique physiological changes called burn shock. Certainly, adequate and timely resuscitation of burn shock will reduce mortality and morbidity. Currently, confidence in the clinical criteria (vital signs and urinary output) for accurate assessment of fluid therapy adequacy is questioned (10).

Navarro et al. performed a study in Mexico for two years on patients admitted to a specialized burn unit and calculated the patients' ABSI. The results revealed that a higher ABSI score led to a higher percentage of sepsis development, longer hospital stays, a lower percentage of skin grafting, and a higher rate of mortality (7). They also reported that it is necessary to manage burn patients in terms of the risk of burns and mortality since the treatment priorities determine the standardized treatment of the patient and act as one of the quality indicators (7).

Several studies have proven that even with acceptable urine output and blood pressure, tissue blood supply may be insufficient. In these cases, plasma BE decreases, and plasma lactate

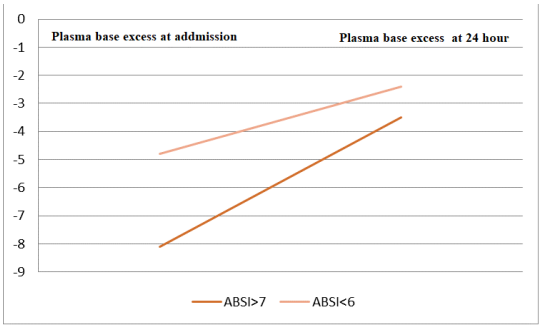

Figure 3: Plasma base excess (BE) changes according to ABSI score

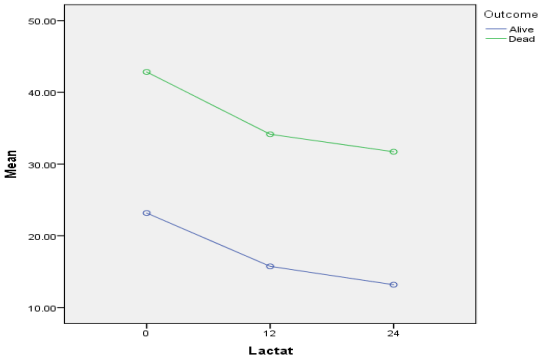

Figure 2: Lactate changes between the deceased and discharged groups

increases (11-14). In the literature review, there are several studies regarding the use of lactate and plasma BE to predict the mortality and morbidity of shock. Some studies reported that a decrease in plasma BE upon admission of multiple trauma patients is the most important predictor of death rate (15, 16).

Some researchers in their studies showed that the reduction of plasma BE in the first 24 h after burn injury is a serious indicator of tissue ischemia due to insufficient resuscitation in burn shock. It is well known that tissue ischemia has a decisive role in the occurrence of systemic inflammation and organ failure (6, 9). The present study and similar studies proved that burn percentage alone does not decrease the plasma BE. Cartotto et al. reported that the reduction of tissue blood supply as a result of insufficient resuscitation is the most important factor in reducing the plasma BE (9).

Table 2: Lactate changes based on ABSI

Time	ABSI≤6	ABSI≥7	P value
0-12 h	-3.8±6.3	-8.4±10.2	<0.001
0-24 h	-6.8±5.4	-11.2±11.4	0.05
12.24 h	-3.6±3.1	-2.3±7.5	0.74

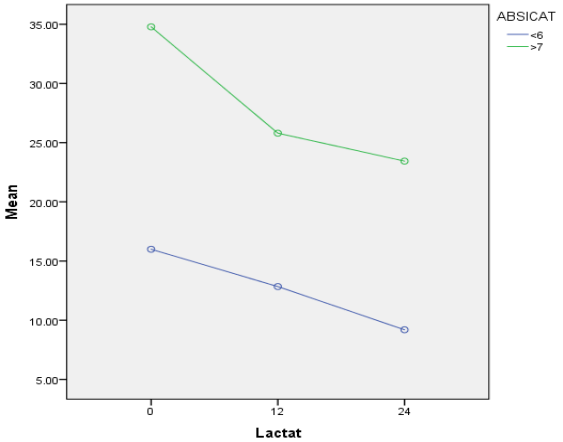

Figure 4: Lactate changes between the deceased and discharged groups in terms of ABSI severity

By evaluating the results of the present study, the hypotheses are raised regarding the greater reduction of plasma BE in some patients, compared to other patients, with almost similar conditions are that, firstly, it is possible that the current fluid therapy formulas in some patients do not cause sufficient resuscitation for unknown reasons, and plasma BE decreases due to cellular ischemia.

Secondly, it is possible that in some patients, despite adequate administration of intravenous fluids, another factor, such as abdominal compartment syndrome, causes an increase in plasma BE, which is neglected in many cases (17, 18).

In a retrospective study in 2007, Cochran investigated the relationship between lactate and plasma BE with mortality in burn patients. They showed that the plasma BE was significantly higher in deceased patients, compared to survived cases (8). In the mentioned study, the age of the patients and the percentage of burns were not matched. The delay in initiating the resuscitation of some patients was another problem of this study. Therefore, with the limitations in their study, it is not possible to generalize it geographically.

The predictive power of the ABSI in diagnosing the prognosis of burn patients has been proven in several studies (19). Lionelli et al. in their study showed that the mortality rate of burn patients can be predicted using the ABSI score obtained from these patients. The increase in mortality causes an increase in ABSI in these patients. These data indicate that great advances have been made in burn care; however, similar successes in inhalation injuries have not been achieved (20).

In another study, Forster et al. stated that ABSI-defined variables confirmed the predictive value of mortality in burn patients. Multivariate analysis shows a significant relationship among increased odds ratio (OR) for mortality in patients over 60 years old with burns greater than 30%. Therefore, despite the significant population changes and medical advances in the last 30 years, the ABSI scoring system is still an accurate and valuable tool in predicting the mortality rate of burn patients (21).

According to the results of the present study and similar studies, physiological indicators (percentage of burn, degree of burn, age, and mucosal burn) alone are not sufficient for predicting mortality and morbidity in burn patients, and it is necessary to use biochemical indicators (lactate or BE of plasma). There are different opinions regarding the value of plasma BE in predicting the prognosis of patients. Cartoto et al. reported that the value of plasma lactate as a marker of shock and resuscitation is higher than plasma BE (8).

According to the mentioned study, the predictive power of plasma lactate is not limited to trauma patients and includes non-trauma cases admitted to the ICU. However, plasma BE is different only upon the first 24 h of admission and in trauma patients who survived or died. The other study showed that plasma BE and plasma lactate are both very reliable predictors of the outcome of burn patients in the first 24 h after the accident. Moreover, the normalization of plasma BE within 24 h is considered the cause of mortality reduction (22). The present study confirmed that the mortality of burn patients can be evaluated using ABSI scores. Pantet et al. in their study stated that the assessment of ABSI score in burn patients provides a better prognosis of mortality in these patients, compared to the results of Baux, Ryan, and BOBI scores (23).

However, it should be noted that revising Baux and ABSI scores are of crucial importance in the vital care and survival of patients. On the other hand, since these scores also have disadvantages, we tried to address these disadvantages by using plasma BE and serum lactate level.

The present study attempted to eliminate the confounding factors in reducing the plasma BE in the studied patients. On the other hand, this study was a prospective one; therefore, care was taken to measure the plasma BE at the determined time points of this study. Another point is that in this study, there were no significant differences among the patients in terms of the type of burn, age, and gender. Considering that abdominal compartment syndrome can cause a decrease in plasma BE, thereby increasing the mortality rate, in addition to the use of plasma BE for monitoring resuscitation in burn patients who require the administration of high volumes of fluid, intra-abdominal pressure should also be measured routinely in all patients of both groups.

It is recommended to be careful in using BE for monitoring resuscitation in burn patients so that all the factors which cause a decrease in plasma BE are considered. These factors include local ischemia of organs, chemical burns, inhalation burns, administration of saline solutions, and abdominal compartment syndrome. The present study raises this serious question again that the current protocols for the resuscitation of burn patients may not meet the needs of some patients. Therefore, it is suggested to investigate this issue in future studies.

Conclusion

The plasma BE is a valuable indicator in the

resuscitation of burn patients due to easy and rapid measurement. The present study confirmed that plasma BE can be used as a valuable tool in the resuscitation monitoring of burn patients along with clinical criteria. On the other hand, the ABSI scoring system is still an accurate and invaluable tool in predicting the mortality of burn patients. Based on the type of study and statistical analysis conducted in this research, it is not possible to definitely consider the predictive power of plasma BE as an independent factor in the mortality and morbidity rates of burn patients; however, the results of the present study confirmed that in determining the outcome of burn patients, in addition to the main factors (age, percentage of burn, depth of burn, and inhalation damage), it is necessary to consider the markers specifying tissue blood supply status, such as plasma BE in the first 24 h after injury. Accordingly, it is suggested to use the ABSI scoring system in addition to plasma BE and plasma lactate for a better and more accurate rediction of mortality in burn patients.

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