

COMPARISON OF THE OUTCOME OF BURN PATIENTS USING ACUTE-PHASE PLASMA BASE DEFICIT

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SUMMARY. *Background.* In recent years, plasma base deficit has been used as a marker to determine the status of tissue perfusion in trauma patients and also to predict the outcome of these patients. This study was performed to investigate the effect of plasma base deficit in predicting burn patient outcome. *Methods.* This prospective cohort study was performed from October 2009 to October 2010 in the acute phase of burn patients who were admitted within 6 h post-injury to Motahari Burn Hospital in Iran. The patients were divided into two groups based on the plasma base deficit in the first 24 h post-injury: group A, in which the mean plasma base deficit was less than or equal to -6 (more negative), and group B, in which the mean plasma base deficit greater than -6. Statistical analysis was performed using SPSS v.16 software. *Results.* Thirty-eight patients were enrolled in each group. The mean plasma base deficit in group A (-7.76 ± 2.18 mmol) was significantly less than that in group B (-1.19 ± 2.82) mmol ($p < 0.05$). Although there was no significant difference between the mean of fluid resuscitation and urine output in the first 24 h after injury between the two groups ($p > 0.05$) and despite removal of interfering factors, there were significant differences between the systemic inflammatory response syndrome and the multiple organ dysfunction syndrome score and the percentage of sepsis between the two groups ($p < 0.05$). The mortality rate in group A (63.2%) was significantly higher than that in group B (36.8%) ($p > 0.05$). *Conclusion.* The plasma base deficit can be used as a valuable marker in the resuscitation of burn patients, along with clinical criteria. Physiological indicators (burn percentage, age, and mucosal burns) are not sufficient to predict mortality and morbidity in burn patients, and it is necessary to investigate the role of biochemical markers such as base deficit in determining the final outcome of burn patients.

Keywords: burn, plasma base deficit, outcome, mortality

Introduction

In patients with burns in over 20% of the body surface area, a high volume of intravascular fluid escapes into the subcutaneous space, resulting in burn shock due to the activity of inflammatory mediators.¹ In these cases, it is necessary to increase tissue perfusion by ensuring adequate intravascular infusion of crystalloid fluid in the first 24 h post-injury. Currently, most centres evaluate the adequacy of fluid therapy on the base of clinical signs (blood pressure, heart rate, urine output), even if some of these patients, despite the normality of their clinical signs, may present an increase in serum lactate or a decrease in plasma base deficit decrease is possible (resistant tissue hypoperfusion or occult hypotension).^{2,3} Occult hypotension (metabolic acidosis) that lasts longer than 12 h has been

shown to increase the chance of infection in trauma patients with high injury severity scores (ISS).⁴ In trauma patients, a decreased plasma base deficit (becoming more negative) in the first 24 h after injury increases the mortality rate and hospital stay.⁵ In recent years, plasma base deficit has been used as an appropriate indicator for assessing the status of tissue perfusion in trauma patients and for predicting their outcome.^{6,9} Although the total body surface area (TBSA) burned is the most important prognostic factor in burn patients, other factors such as age, underlying diseases, and inhalation injury are important in burn patient prognosis. The purpose of this study was to answer the question whether significantly decreased plasma base deficit in the first 24 h after burn injury plays any part in burn patient prognosis.

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Materials and methods

This prospective cohort study was performed from October 2009 to October 2010 in the acute phase of burn injury. It included patients with over 20% TBSA burns admitted within 6 h of injury to Motahari Burn Hospital (inclusion criteria). Patients with electrical or chemical burns or inhalation injury, and patients admitted more than 6 h after injury were excluded from the study (exclusion criteria). In all cases the therapeutic and diagnostic management was performed according to standard burn care protocols, the Parkland formula being used for fluid therapy in the first 24 h.

The plasma base deficit was measured immediately after admission and then every 8 h in the first 24 h; the plasma base deficit values did not change the prescribed Ringer's lactate volumes. Vital signs (heart rate, respiratory rate, blood pressure, body temperature, volume of urine output) were measured every 6 h. Laboratory tests (complete blood test, blood urea nitrogen, creatinine, electrolytes, fasting blood sugar, coagulation tests, and arterial blood gases) were performed daily. Liver function and serum total protein and albumin were measured twice a week. Other laboratory tests (e.g. blood culture) were performed as needed.

Clinical and laboratory SIRS (systemic inflammatory response syndrome) criteria were recorded for 10 days after admission. SIRS criteria included: leucocytosis or leucopenia ($4000 > WBC > 12000$), hyperthermia, or hypothermia ($36^{\circ} > T > 38^{\circ}$), tachypnoea ($RR > 0$), and tachycardia ($PR > 90$). Every day, clinical and laboratory signs of SIRS were evaluated in all patients based on the criteria approved by the American College of Chest Physicians/Society of Critical Care Medicine,¹⁰ each patient receiving a score of zero to four. In the paediatric group, the heart and respiratory rates were age-adjusted. Clinical or laboratory tests were performed daily in all the patients in order to diagnose sepsis. Using the the Marshal protocol,¹¹ which considers six parameters and scores each between zero to four, MODS (multiple organ dysfunction syndrome) scores were calculated for all patients. The Abbreviated Burn Severity Index (ABSI) was also determined for all patients based on Tobiasen's ABSI.¹² Patients were divided into two groups based on the mean of the first 24 h *p* base deficit (BD): group A ($BD \leq -6$) and group B ($BD > -6$). Collected data were analysed using SPSS v.16 software (SPSS, Chicago, Inc). Quantitative variables were compared using the independent sample t test, and non-parametric variables were compared using the chi-square test. This research was approved by the Tehran University of Medical Sciences Research Subjects Review Board.

Results

Thirty-eight patients in each group were studied, and it was found that the mean plasma base deficit in group A (-7.76 ± 1.18) was less than in group B (-1.19 ± 2.82). This difference was significant ($p < 0.05$) (Table I) (Fig. 1).

There was no significant difference in mean age between the two groups (Table I). The gender distribution in the two groups was almost identical and there was no significant difference using the chi-square test ($p > 0.05$) (Table II). Using the Independent sample t Test, there were no significant differences between the two groups in the mean percentage of total body surface area burned, the mean volume of fluid administered, and urine output in the first 24 h after injury ($p > 0.05$) (Table I) (Fig. 2). Escharotomy was performed in 34.2% of patients in group A and 21.1% of patients in group B ($p > 0.05$) (Table II). The average

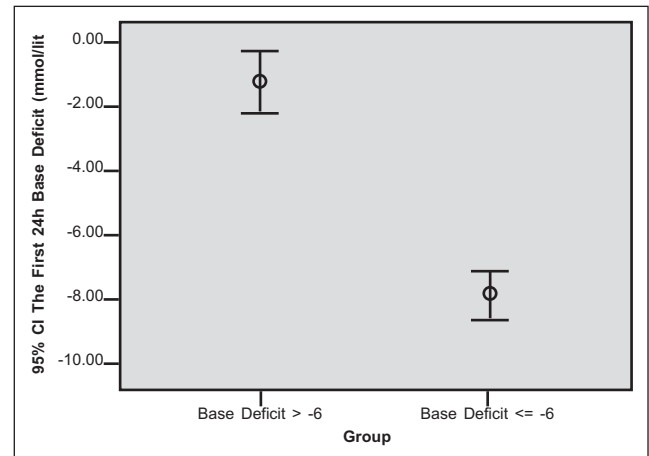


Fig. 1 - Comparison of mean plasma base deficit (first 24 h after burn injury) between groups A and B.

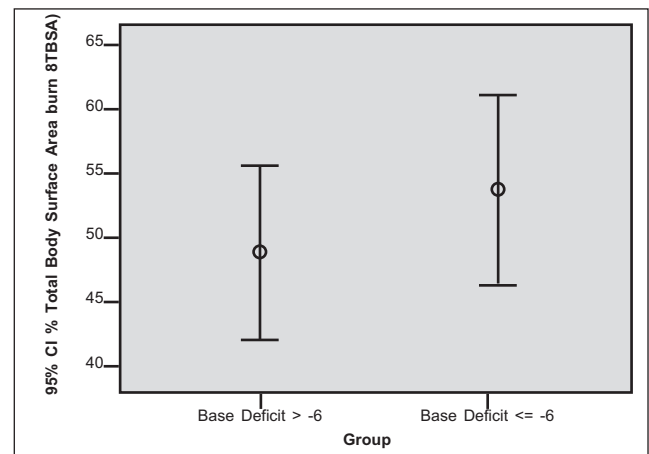


Fig. 2 - Comparison of mean TBSA between groups A and B.

Table I - Comparison of age, mean base deficit (first 24 h), TBSA, mean hospital stay, number of surgical operations, urine output, mean ABSI Score, mean MODS Score, mean SIRS score between groups A and B

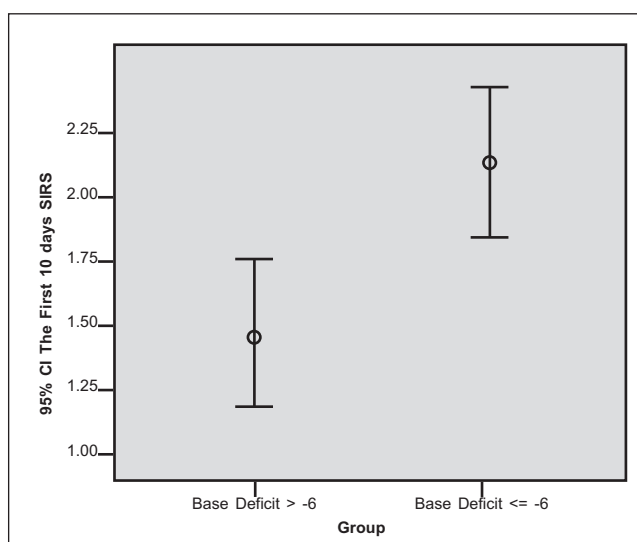
	Group A (BD ≤ -6) No. 38	Group B (BD > -6) No. 38	df	<i>p</i>
Mean BD (first 24 h) (mmol/±1)	7.76 ± 1.18	-1.19 ± 2.82	74	<i>p</i> < 0.05
Age (yr)	29.92 ± 19.88	31.84 ± 12.12	74	<i>p</i> > 0.05
TBSA ^a (%)	53.74 ± 22.46	48.79 ± 0.49	74	<i>p</i> > 0.05
Mean number of hospital stay (days)	17.37 ± 13.39	15.71 ± 8.98	74	<i>p</i> > 0.05
Mean number of surgical operations	2.11 ± 2.09	2.18 ± 1.69	74	<i>p</i> > 0.05
Urine output (ml/kg/h)	1.79 ± 0.86	1.71 ± 0.68	61	<i>p</i> > 0.05
Mean ABSI ^b score	7.98 ± 2.96	7.85 ± 2.08	74	<i>p</i> > 0.05
Mean MODS ^c score	6.24 ± 4.78	1.42 ± 3.80	73	<i>p</i> < 0.05
Mean SIRS ^d score	2.06 ± 0.81	1.45 ± 0.80	74	<i>p</i> < 0.05

p < 0.05: There was a statistically significant difference between the two groups based on the independent sample t test
p > 0.05: There was no statistically significant difference between the two groups based on the independent sample t test
^aTBSA: Total body surface area (percentage of burn)
^bABSI: Abbreviated burn index
^cMODS: Multiple organ dysfunction syndrome
^dSIRS: Systemic inflammatory response syndrome

Table II - Comparison of sex, escharotomy, sepsis, and death between groups A and B

		Group A (BD ≤ -6) 38	Group B (BD > -6) 38	<i>p</i>
Sex %	M	52.6	63.2	> 0.05
	F	47.4	36.8	
Escharotomy (%)		34.2	21.1	> 0.05
Sepsis (%)		57.9	21.1	< 0.05
Death (%)		63.2	36.8	< 0.05

p > 0.05: There was a statistically significant difference between the two groups based on non-parametric chi-square
p > 0.05: There was no statistically significant difference between the two groups based on non-parametric chi-square test

**Fig. 3** - Comparison of first 10 days mean SIRS score between groups A and B.

number of surgical interventions and hospital stay was, respectively, 2.11 ± 2.09 times and 17.37 ± 8.98 days in group A and 2.18 ± 1.69 times and 15.71 ± 8.98 days in group B ($p > 0.05$) (Table I). The mean ABSI scores in both groups were not significantly different ($p > 0.05$) (Table I). The mean MODS scores during hospital stay and SIRS scores in the first ten days of hospitalization were significantly higher in group A than in group B (Table I) (Fig. 3). Also, 57.9% and 21.1% of group A and group B patients, respectively, suffered from sepsis; based on the chi-square test, this difference was significant ($p < 0.05$) (Table II). The mortality rate in group A was higher than that in group B (63.2% vs. 36.8%) ($p < 0.05$) (Table II).

Discussion

Severe burns cause unique and serious physiological changes, i.e. burn shock. Appropriate early resuscitation in burn shock decreases mortality and morbidity but it now seems that the use of clinical criteria (vital signs, urine

output) to assess the adequacy of fluid therapy is not sufficient.¹³ Several studies have shown that despite normal blood pressure and adequate urine output, tissue hypoperfusion may occur, leading to plasma base deficit decreases and plasma lactate increases.^{6,7,14,15}

The literature contains various studies on the use of plasma base deficit and plasma lactate to predict mortality or morbidity in trauma patients. Some articles report that reducing the plasma base deficit from the start of admission was the main prognostic factor for mortality in multiple trauma patients;^{5,16} in such cases the reduced plasma base deficit was of course not due to hyperchloreaemic acidosis.¹⁷ A base deficit of $<$ or $= -6$ is a marker of severe injury and significant mortality in all trauma patients,¹⁸ for which reason the value -6 of BD was set as the limit for evaluating the role of BD in the prognosis of burn patient injuries.^{7,14}

This cohort study attempted to eliminate interventional factors. All patients with chemical or electrical burns, inhalation injury, and carbon monoxide poisoning were excluded. There was no significant difference between the groups with regard to the frequency of escharotomy, and consequently the reduction of local tissue perfusion (e.g. impaired circulation in the limbs) did not cause significant plasma base deficit reduction. While the number of patients in the two groups was similar (38 patients per group), the mean TBSA, age, and the percentage of the two genders in the groups was not significantly different.

In this study, only patients who were admitted to the hospital within 6 h of injury were enrolled. Therefore, there was no delayed resuscitation in any patients.

In both groups, standard fluid therapy was performed according to the same protocols in the first 24 h after injury (without the use of saline solutions). This study used urine output to gauge burn resuscitation (30-50 ml/h in adults and 1-1.5 ml/h in children). There were no significant differences between the two groups in the urine output in the first 24 h after injury ($p > 0.05$) (Table I). The mean urine output in both groups of patients was over 1.5 ml/kg/h in the first 24 h after injury, which according to reliable sources is adequate.¹ Thus, considering the clinical criteria involved, it would appear that an adequate volume was administered to all patients. In view of the aim of the study we did not use BD as a guideline for burn resuscitation. One question that arises is why there were significant differences in the mean plasma base deficit in the first 24 h, the SIRS score in the first ten days of hospitalization, the MODS score, and the mortality rate between the two groups despite the fact that there were no significant differences between the two groups in the mean volume of fluid administered, urine output in the first 24 h after injury, and the removal of interfering factors.

The results of our study are similar to those of Cartotto and Choi,^{7,14} except that in our study the number of

patients in the two groups was equal and the sample size was larger. In this study, interfering factors - including chemical burns, electrical injuries, inhalation burns, and CO poisoning, were excluded. Additionally, the mean age and burn percentage in the two groups were not significantly different.

Some studies have confirmed that inadequate resuscitation in the first 24 h after burn injury decreases the plasma base deficit.^{7,14,15} Tissue ischaemia has an important role in creating systemic inflammation and organ failure.¹⁹ The mean total body surface area burned in the two groups did not significantly differ, but the mean difference in the plasma base deficit between the two groups was significant. Our study and similar reports have proved that, contrary to previous thinking, the burns percentage is not the only cause of the plasma base deficit decrease in burn injury. According to Cartotto's report, decreased tissue perfusion due to inadequate resuscitation was the most important factor in reducing the plasma base deficit.^{7,12} Several hypotheses consider why there is a further reduction of the plasma base deficit in some patients but not in others in almost the same conditions:

1. it is probably due to unknown reasons - present-day fluid therapy formulae are inadequate in some patients;
2. in some patients, despite sufficient resuscitation, other factors such as abdominal compartment syndrome reduce the plasma base deficit.

In some studies, the predictive power of the ABSI in the establishment of the prognosis of burn patients has been demonstrated.¹² In this study, ABSI was calculated for both groups: there was no significant difference between the two groups, but the mean MODS and SIRS scores, as also the incidence of sepsis and mortality, were significantly higher in group A ($BD \leq -6$).

Our results and those of other studies²⁰ showed that physiological indicators (e.g. burn percentage, degree of burn, mucosa burn, age) were not sufficient for predicting mortality and morbidity in burn patients and that it was also necessary to use biochemical parameters (lactate or plasma base deficit). The value of the plasma base deficit in predicting the prognosis of burn injury patients is controversial. According to Husain's study, plasma lactate is more valuable as a marker of shock and resuscitation than the plasma base deficit, and the predictive power of plasma lactate is not limited to trauma patients, as non-trauma patients were admitted to the ICU.⁸ The main finding of Andel et al.²¹ was that plasma base deficit and plasma lactate were both very reliable predictors of outcome in burn patients in the first 24 h after injury. When the plasma base deficit returned to a normal range within 24 h, mortality was reduced.²¹

In 2007, a retrospective study by Cochran et al. evaluated the correlation of plasma lactate and plasma base

deficit with mortality in burn patients.⁹ The study was unable to confirm a relationship between an extremely negative base deficit and increased complications, including ARDS or SIRS/sepsis.⁹ In the same study, the plasma base deficit at 24 h after admission in patients who died was significantly lower than it was in survivors. These findings are limited for several reasons. As the research was conducted retrospectively, serial data were not collected for the plasma base deficit during the first 48 h after admission. The study's retrospective nature also did not permit the matching of patients by age and TBSA. Additionally, the delay in resuscitation due to the patients' prolonged transport time was a problem for the study. As noted, the "conclusion generated by this study may not be appropriate in other geographic setting."⁹

Our study was prospective and we were therefore able to collect serial data for the plasma base deficit during the first 24 h after injury in all patients, and we were able to match patients for age and TBSA. Additionally, in our research, there was no delay in resuscitating patients and as far as possible we eliminated interventional factors.

As limb ischaemia, chemical burns, inhalation burns, the administration of saline solution, and abdominal compartment syndrome also reduce BD, these factors must be considered when using BD to monitor the resuscitation sta-

tus of burn patients.

One of the limitations of our study was that abdominal pressure was not routinely measured in all patients in both groups, and the association between the development of the abdominal compartment syndrome and the more negative BD was therefore not clear.

Conclusion

We can say, on the basis of our findings and of previous studies, that the plasma base deficit is a valuable tool for monitoring the resuscitation condition of burn patients.

We also have to say that we cannot, on the basis of the method used and the statistical analysis performed in our study, pronounce any definitive comment on the predictive power of the plasma base deficit as an independent factor in the clinical outcome of burn patients.

Our results emphasize the fact that in addition to the physiological factors (age, TBSA, depth of burn, inhalation injury), it is necessary to investigate the role of biochemical markers, such as base deficit, in the determination of burn patient outcome.

This study raises the question whether current resuscitation formulas are adequate for all burn patients.

RÉSUMÉ. *Données générales.* Pendant ces dernières années, le déficit de plasma de base a été utilisé comme marqueur pour déterminer l'état de la perfusion tissulaire chez les patients traumatisés et aussi pour prédire le résultat final de ces patients. Cette étude a été réalisée pour étudier l'effet du déficit de plasma de base dans la prédiction des résultats des patients brûlés. *Méthodes.* Cette étude prospective de cohorte a été réalisée du mois d'octobre 2009 jusqu'à octobre 2010 au moment de la phase aiguë des patients atteints de brûlures qui ont été admis auprès de l'Hôpital Motahari en Iran dans les premières 6 h après l'incident. Les patients ont été divisés en deux groupes sur la base de leur déficit de plasma de base dans les premières 24 h post-traumatiques, que nous avons défini comme suit: le groupe A, dans lequel le déficit moyen de plasma de base était inférieur ou égal à -6, et le groupe B, où le déficit moyen de plasma de base était supérieur à -6. L'analyse statistique a été réalisée en utilisant logiciel SPSS v.16. *Résultats.* Trente-huit patients ont été inclus dans chaque groupe. Le déficit plasmatique moyen de base dans le groupe A (-7,76 ± 2,18 mmol) a été sensiblement inférieur à celui du groupe B (-1,19 ± 2,82) mmol ($p < 0,05$). Même s'il n'y avait pas de différence significative entre le volume moyen de liquide de réanimation et la production d'urine dans les 24 premières h après la brûlure entre les deux groupes ($p > 0,05$) et en dépit de l'élimination des facteurs interférants, il y avait des différences significatives entre le syndrome de la réponse inflammatoire systémique et le score du syndrome de la dysfonction organique multiple et le pourcentage de septicémie entre les deux groupes ($p < 0,05$). Le taux de mortalité dans le groupe A (63,2%) était significativement plus élevé que dans le groupe B (36,8%) ($p > 0,05$). *Conclusion.* Le déficit de base de plasma peut être utilisé comme un marqueur de valeur dans la réanimation des patients brûlés, comme aussi certains critères cliniques. Les indicateurs physiologiques (pourcentage corporel brûlé, l'âge, et les brûlures des muqueuses) ne suffisent pas pour prédire la mortalité ou la morbidité des patients brûlés, et il est donc nécessaire d'étudier le rôle des marqueurs biochimiques tels que le déficit de base pour déterminer le résultat final finaux de cette catégorie de patients brûlés.

Mots-clés: brûlure, déficit de base de plasma, résultat final, mortalité

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The authors of this article disclaim any financial and personal dealings with other people or organizations, including the National Institute of Health (NIH), Wellcome Trust, Howard Hughes Medical Institute (HHMI), and other(s) with regard to the performance of this study.

This paper was accepted on 10 December 2011.



ANNALS OF BURNS AND FIRE DISASTERS

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