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Article

Predictive analysis of lactate clearance on the prognosis of patients with large burns

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Abstract: Aims: To examine burn shock monitoring and the connection between lactate clearance and shock prognosis in individuals with severe burns. **Materials and methods:** This retrospective analysis comprised 100 patients with significant burns treated in our hospital between August 2017 and August 2021. The patients were split into two groups based on whether they survived or not: 50 cases each in the survival and death groups. Both groups had their blood lactate levels, partial pressure of oxygen, and other relevant indices tested. Analysis was done on the correlation between lactate level, lactate clearance, and death as well as the association between lactate clearance and prognosis at each time and point. **Results:** The lactate clearance rates at 6 h, 12 h, 24 h and 24 h in the survival group were greater than those in the death group, and the differences were significant ($p < 0.05$). The lactate clearance rates at each time point were compared at a cut-off of 20%, and patients with 6 h and 12 h blood lactate clearance rates ≥20.0% had lower prognostic morbidity and mortality rates than those <20.0%, with a significant difference ($p < 0.05$). **Conclusion:** Lactate clearance is directly correlated with the prognosis of patients with severe burns, and survivors also have a high clearance rate. As a result, in patients with severe burns, lactate clearance monitoring during the shock phase can improve prognostic prediction and enable early treatment plan modification based on outcomes.

Keywords: lactate clearance; large burns; predictive analysis; lactate levels; partial pressure of blood oxygen

1. Introduction

The extravasation of plasma-like fluid from sizable traumatized sites causes hypovolemic shock in the pathological conditions of severe burn shock, and the redistribution of blood represents a significant alteration in the body's hemodynamics [1]. It results in ischemia of tissue cells, increased hypoxia metabolism, hyperlactatemia, excessive blood lactate generation, and a marked reduction in the perfusion of many tissues and organs [2]. Researchers have conducted numerous studies on the metabolism of lactate in vivo, and blood lactate is receiving increasing attention as an indicator of tissue hypoxia by measuring lactate to reflect systemic tissue perfusion deficit and the degree of tissue organ oxygen debt [3].

Several studies have reported a significant correlation between both blood lactate levels and the clearance of blood lactate during treatment and prognosis [4]. The balance of lactate in the blood relies on the amount produced versus consumed to maintain it, and in anaerobic conditions, where cells increase lactate production, a lactic acidemic state occurs and is associated with mortality in critically ill patients [5]. Many recent studies have looked at the level of lactate and its clearance in relation to clinical outcomes [6]. In burn patients, the morbidity and mortality rate does not decrease significantly even when intensive treatment such as early fluid resuscitation, mechanical ventilation, and infection control is given [7]. One of the key metabolic markers that responds to tissue microperfusion in patients is lactate, and inadequate tissue microperfusion in burn patients is a major contributor to their death [8]. Because of this, retrospective dynamic examination of blood lactate enhances salvage survival and offers predictive value for early identification, management, and prognosis determination of acute diseases [9,10]. Based on this, we investigated the prognostic significance of lactate clearance by doing a prediction study on the prognosis of patients with significant burns.

2. Material and methods

2.1. Research object

A retrospective analysis was carried out by picking 100 instances among the patients who had treatment at our hospital between August 2017 and August 2021 and had severe burns. Based on their survival or death, the patients were divided into two groups: 50 patients in each group for survival and death. Within eight hours of their injuries, all enrolled individuals were admitted to the hospital.

Meaning of severe burns greater than 50% of the total burn area or more than 30% of the total burn area with burns of at least 10% in the third degree. No poisoning or burns from chemicals. not a history of serious organ illness. At admission, the blood lactate level was less than 2 mmol/L, meaning it was around 6.3 ± 1.2 h after the injury.

Criteria for inclusion and removal qualifications for Inclusion: fulfills the American Guidelines for Resuscitation of Burn Shock’s diagnostic requirements for significant burns. A minimum of 90 mmHg in the systolic blood pressure or a mean arterial pressure of less than 65 mmHg that lasts for at least an hour, or a need for vasopressor medication to keep the blood pressure stable. Persistent hypotension that cannot be explained despite receiving appropriate fluid resuscitation. comprehensive clinical and imaging data that defies alternative explanations.

Criteria for Exclusion:

(1) comorbid malignancies, diabetes mellitus, or chronic liver or renal insufficiency that was treated with metformin in the past.

(2) the existence of alkalosis; pregnancy; under-18 age; and severe renal and hepatic impairment.

(3) Individuals whose relatives willingly forego additional resuscitation care as a result of medication-induced acidosis.

Criteria for termination of the trial

Those whose disease has worsened during the course of treatment and who need to adjust their treatment regimen.

2.2. Methods

Early goal-directed treatment (EGDT) was given to every patient who was enrolled, and pathogen specimens were held before antibiotics were given. Among the specific therapeutic methods were:

Antibiotics: after three hours of emergency care or one hour of critical care, broad-spectrum antibiotics were administered. Patients with acute respiratory distress syndrome or acute lung injury owing to infection may benefit from mechanical ventilation. Renal replacement therapy and glucose management/sedation when necessary.

Monitoring: Note the following: mechanical ventilation, type and dosage of vasoactive medicines, arterial partial pressure of oxygen (PO_2), central venous pressure (CVP), mean arterial pressure (MAP), and the patient's 28-day prognosis at admission.

Dynamic monitoring: A German GEMPremier 3000 automated analyzer was used to detect the blood lactate level after 2 mL of venous blood was drawn using heparin anticoagulation tubes.

2.3. Observation indicators

All patients were monitored on admission and their arterial partial pressure (PO_2), central venous pressure (CVP), mean arterial pressure (MAP), type and dose of vasoactive drugs, mechanical ventilation, and prognosis for 28 days were recorded. and the prognostic outcome of the patients at 28 days. Basal blood lactate values at the time of admission and at the end of the shock period (72 h after injury) were determined using a Premier 3000 blood gas analyzer (American Laboratory Instruments). The lactate clearance rate during the shock period was calculated according to the formula correction: (basal blood lactate value − blood lactate value at the end of the shock period) ÷ basal blood lactate value × 100%.

2.4. Statistical analysis

All statistical data in this study were entered into excel software by the first author and the corresponding author respectively, and the statistical processing software was SPSS25.0 for calculation. Repeated measures analysis of variance between groups was used to measure the measurement expressed as mean ± standard deviation ($X \pm \mathbf{S}$). material. Count data expressed as a percentage (%) were tested by χ^2. Univariate and Logistic multivariate regression analysis was used to compare the influencing factors, and the risk factors with significant differences were screened. Correlation test using logistic regression linear correlation analysis. Included data that did not conform to a normal distribution were described by M(QR), using the Mann-Whitney test. All statistical tests were two-sided probability tests, The statistical significance was $p < 0.05$.

3. Results

3.1. General information comparison

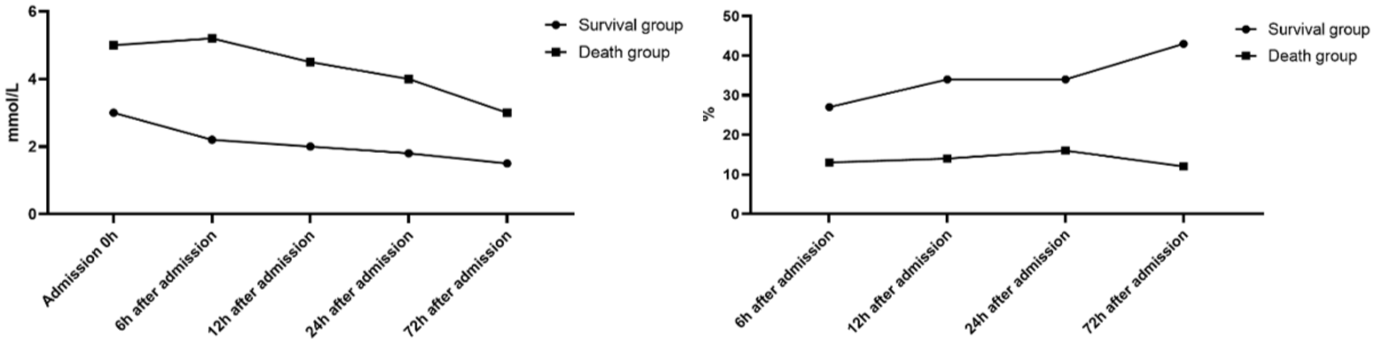
There was no statistically significant difference between the two groups by *t*-test and chi-square test ($p > 0.05$) when comparing the general data such as gender, mean age, body mass index, MAP, CVP, and PO_2. See **Table 1**.

Table 1. Comparison of general information between the two groups [n, ($\overline{x} \pm s$)].

	Gender (male/female)	Average age (months)	Body mass index (kg/m^2)	MAP (mmHg)	CVP (mmHg)	PO_2 (mmHg)
Death group (50)	23/27	16.63 ± 8.32	27.37 ± 3.67	62.27 ± 1.14	16.34 ± 3.25	62.25 ± 0.62
Survival group (50)	22/28	16.52 ± 8.31	26.93 ± 3.25	62.37 ± 1.20	16.73 ± 2.24	62.27 ± 0.31
χ^2/t	0.040	0.066	0.635	−0.427	−0.699	−0.204
p	0.841	0.947	0.527	0.670	0.486	0.839

3.2. Comparison of lactate level measurements

Compared with the blood lactate concentration at 0 h after admission, 6 h, 12 h, 24 h and 72 h after admission, the death group was higher than the survival group ($p < 0.05$). The 6 h, 12 h and 24 h lactate clearance rates of the survival group were higher than those of the death group, and the difference was significant ($p < 0.05$), but there was no significant difference between the survival group and the death group in the 72h lactate clearance rate ($p > 0.05$). see **Figure 1a,b**.



(a) **(b)**

Figure 1. Comparison of tumor marker levels. **(a)** Blood lactate concentration; **(b)** blood lactate clearance.

All the measurement and comparison data of lactate level in this study were entered into excel software by the first author and the corresponding author respectively, expressed as mean ± standard deviation, and the statistical processing software was SPSS25.0 for calculation. Compared with the blood lactate concentration at 6 h, 12 h, 24 h and 72 h after admission, the death group was higher than the survival group ($p < 0.05$). The 6 h, 12 h and 24 h lactate clearance rates of the survival group were higher than those of the death group, and the difference was significant ($p < 0.05$), but there was no significant difference between the survival group and the death group in the 72h lactate clearance rate ($p > 0.05$).

3.3. Comparison of lactate clearance counts

Comparing the lactate clearance rate at each time point with 20% as the cutoff point, the patients with blood lactate clearance rate ≥ 20.0% at 6 h and 12 h were lower than the patients with prognosis less than 20.0%, and the difference was significant ($p < 0.01$), 24 h and 72 h mortality rate difference was not statistically significant ($p > 0.05$). **Figure 2**.

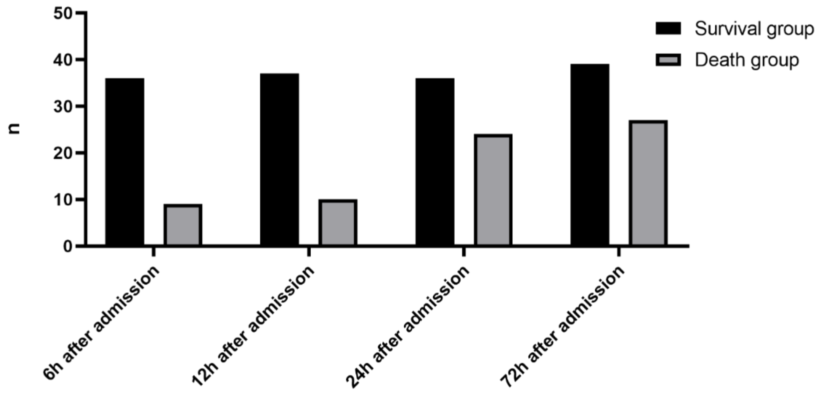


Figure 2. Comparison of lactate clearance counts.

All the lactate clearance rate count comparison data in this study were entered into excel software by the first author and the corresponding author respectively, expressed as integers, and the statistical processing software was SPSS25.0 for calculation. Chi-square analysis was used to find that the lactate clearance rate at each time point was calculated. Taking 20% as the cut-off point for comparison, the patients with 6 h and 12 h blood lactate clearance rate ≥20.0% had lower mortality than those with <20.0%, and the difference was significant ($p < 0.01$). There was a difference in 24 h and 72 h mortality There was no statistical significance ($p > 0.05$).

4. Discussion

Blood lactate clinical monitoring, previously practiced in China, is crucial for guiding treatment and assessing patient prognosis [11,12]. Clinical application still reveals the following flaws, though: For certain patients, the prognosis is not significantly correlated with basal blood lactate levels [13]. Severe burn patients have varying baseline statuses; those with hepatic insufficiency or those who have recently had surgery have higher basal blood lactate readings, and some will only improve with active treatment [14]. Therefore, blood lactate levels alone do not adequately reflect the tissue oxygenation status and lack early continuous monitoring, in order to compensate for the deficiencies of single measurement of blood lactate [15]. The concept of continuous dynamic monitoring of blood lactate and the concept of "lactate clearance" has been gradually developed in clinical practice, and clinical practice has shown that this index can better determine the prognosis of patients [16]. The present study also confirmed the close relationship between prognosis and lactate clearance in patients with severe burns: patients with high clearance had a better prognosis, and those who survived also had a higher clearance [17]. Therefore, monitoring lactate clearance during the shock period in patients with severe burns can better predict the prognosis and allow early adjustment of the treatment plan based on the results, and more detailed monitoring of lactate clearance may have more obvious guidance for the treatment of patients with severe burns [18].

The low patient death rate and the quicker decline in blood lactate concentration in our study further support the notion that the condition is directly related to the blood lactate concentration, with blood lactate production decreasing and clearance increasing as the condition improves and the infectious shock's acidosis is corrected [19]. Clinical dynamic monitoring of patients' arterial blood lactate might indirectly represent their organ functional state and illness severity if the arterial lactate level keeps rising, which signals severe tissue hypoxia and aberrant organ function [20]. Blood lactate concentration is influenced by a variety of factors, and in recent years the concept of lactate clearance has been proposed to calculate lactate clearance by dynamically monitoring blood lactate levels, and lactate clearance at early onset not only reflects metabolic disorders and patient response to treatment at the early stage of severe infection, but may also be directly related to prognosis [21]. Results have shown that as lactate concentration decreases, especially in patients with significantly lower 6 h lactate clearance, mortality is greatly reduced [22]. Previously, there was a lack of effective monitoring of burn shock patients, and the duration of the burn shock period was empirically considered to be 48 h. When the urine volume was maintained at about 40 mL/h, it indicated that the hypoperfusion perfusion condition of the tissue had been effectively corrected [23]. Even though the patients in our study were rehydrated for up to 72 h, and the urine volume was maintained at around 40mL/h, the blood lactate concentration was still at a high level, suggesting that the tissues were still in a hypoxic state and that tissue perfusion was not adequate [24]. The rehydration regimen used in the patient ensured rapid and adequate fluid input into the organism and prompted an increase in urine volume to 100 mL/h, resulting in a largely low blood lactate concentration, which significantly improved the hypoxic condition of tissue cells.

Our findings are consistent with earlier studies in the literature [25] and show that blood lactate concentrations were significantly higher in the deceased group than in the surviving group at all time points tested. This suggests that the condition of tissue perfusion is not indicative of partial pressure of blood oxygen. Blood lactate concentrations can be dynamically and continuously monitored to know clinically whether the treatment given has an effect on the ischemia and hypoxia of the tissues and organs. This is more useful for prognosis and more clinically meaningful than the detection of a specific lactate value alone [26]. When comparing the blood lactate clearance rates at various time points between the surviving and dead groups, we found that the lactate clearance rates at 6 h, 12 h, and 24 h were significantly higher in the surviving group than in the dead group, suggesting that the lactate clearance rates at these three time points may be a factor affecting the prognosis of the patients. Burn injury makes oxygen delivery inadequate, leading to mitochondrial hypoxia, and under hypoxic conditions mitochondrial oxidative phosphorylation fails and energy metabolism becomes dependent on anaerobic enzymes [27]. Anaerobic glycolysis sharply increases the intracellular lactate content, and prolonged cellular hypoxia allows lactate to diffuse into the bloodstream [28]. The excretion of lactate depends mainly on hepatic gluconeogenesis, the tricarboxylic acid cycle, and renal secretion, and abnormalities in either production or elimination of lactate in the body can lead to lactate accumulation in the blood [29]. Decreased lactate clearance is usually the most important cause of increased blood lactate, and decreased lactate clearance can be used to reflect the severity of the disease in Chengdu, where inadequate perfusion and hypoxia in tissues are assessed by lactate levels, which are easy to monitor clinically and highly acceptable to patients [30]. In patients with burns and severe clinical manifestations of infection, timely detection of blood lactate concentration and correction of blood lactate clearance is particularly important.

There are certain limitations in our study: the samples selected were from our hospital inclusion exclusion are subjective and the number is small, and the findings may not be generalizable; we failed to study in depth the clinical treatment effect of long follow-up of patients with large burns. In conclusion, the prognosis of patients with severe burns is closely related to the lactate clearance rate, and surviving patients also have a high clearance rate, so monitoring the lactate clearance rate during the shock period in patients with severe burns can better predict the prognosis, and the treatment plan can be adjusted early according to the results.

5. Conclusion

This study showed a strong correlation between lactate clearance—which was higher in survivors—and the prognosis of patients with severe burns. Consequently, lactate clearance monitoring during shock in patients with severe burns may improve prognostic prediction and enable early treatment regimen modification based on outcomes. The clinical significance of lactate clearance as a crucial prognostic factor for burn victims is supported by this investigation. Nevertheless, the results might not be broadly generalizable because the sample selection was small and subjective, and the samples were limited to our institution. Secondly, we were unable to thoroughly examine the clinical outcomes of patients with significant burns during long-term follow-up. Consequently, in order to confirm the generalizability and reliability of our findings, future research should take into account bigger sample sizes and multicenter studies. Further research involving multiple centers and a substantial sample size is necessary to confirm the applicability of lactate clearance as a predictive factor. To determine the correlation between lactate clearance and the long-term prognosis, conduct long-term follow-up investigations. Examine how various therapy approaches affect the rate of lactate clearance and look for the best possible treatment plans. comprehensive investigation to identify the underlying mechanisms in the association between lactate clearance rate and physiological and pathological processes, such as tissue microperfusion and cellular metabolism. With more knowledge about lactate metabolism and prognostic assessment in patients with severe burns, clinical treatment options will be improved, and patient survival and quality of life will be improved.

Author contributions: Conceptualization, YM and PW; methodology, YM; software, YM; validation, YM, PW and XW; formal analysis, YM; investigation, YM; resources, PW; data curation, PW; writing—original draft preparation, XW; writing—review and editing, XW; visualization, XW; supervision, YM; project administration, XW; funding acquisition, XW. All authors have read and agreed to the published version of the manuscript.

Ethical approval: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Eastern Theater Command General Hospital (protocol code CH20240655D and 09/06/2024 date of approval).

Acknowledgments: This clinical trial strictly adheres to all principles of the Helsinki Declaration. Prior to the trial, we provided detailed explanations of the study’s purpose, procedures, potential risks, and benefits to all participants, and ensured they signed

informed consent forms after fully understanding the information.

Conflicts of interest: The authors declare no conflict of interest.

Notes

[1] Arterial oxygen partial pressure (PO_2), central venous pressure (CVP), mean arterial pressure (MAP), mechanical ventilation, vasoactive medication type and dosage, and a 28-day prognosis are all monitored upon admission.

[2] Measured at admission and at the conclusion of the shock phase (72 h after injury), the blood lactate value.

[3] Lactate clearance is computed as follows: basal blood lactate value ÷ blood lactate value at the conclusion of the shock period × 100%.

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