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Original Article

Correlations of blood lactic acid and procalcitonin levels with prognosis of septic shock

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Abstract: Objective: To investigate the correlations between the lactate acid and procalcitonin levels and prognosis of septic shock. Methods: A total of 70 critically ill patients with confirmed septic shock admitted to the intensive care unit (ICU) were enrolled in the present study. They were assigned to the survival control group or the death group according to the clinical outcomes after standard care. The differences in the Acute Physiology and Chronic Health Evaluation II (APACHE II) score and the levels of blood lactic acid and procalcitonin at 0 h, 6 h and 24 h after admission to the ICU, respectively were compared among the patients in the two groups. Pearson correlation was employed to assess the association of diverse outcomes with the levels of blood lactic acid and procalcitonin and the APACHE II score, and the association of the APACHE II score with the blood lactic acid and procalcitonin levels as well. Results: The blood lactate acid and procalcitonin levels at different time points were significantly lower among the patients in the survival control group than those in the death group (All P=0.000); as compared tothe patients in the death group, a substantial reduction in the APACHE II score was noted among those in the survival control group (P=0.000); among all the patients, their prognosis was negatively correlated with the blood lactate acid level (r= -0.71, P=0.014) the procalcitonin level (r=-0.84, P=0.019) and the APACHE II score (r=-0.74, P=0.009) whereas the APACHE II score was positively correlated with the blood lactate acid level (r=0.68, P=0.006) and the procalcitonin level (r=0.77, P=0.012). The receiver operating characteristics (ROC) curves indicated that the levels of blood lactic acid (P=0.013) and procalcitonin (P=0.009) were significantly predictive of the mortality of the patients with septic shock. Conclusion: The blood lactate acid and procalcitonin levels were correlated with prognosis of patients with septic shock, with higher levels of blood lactate acid and procalcitonin indicating worse prognosis.

Keywords: Blood lactate acid, procalcitonin, septic shock, prognosis

Introduction

Septic shock is a common critical disease among critically ill patients in the ICU, which threatens health of the patients [1]. Previous studies have reported that the mortality from septic shock is 1/4 or more of all the deaths in the ICU setting [2, 3]. As a result, in addition to standard care, it is of significance to find suitable and effective biomarkers and evaluate the prognosis of patients timely and accurately to reduce the complications and mortality of the patients [4].

In the past, the methods of blood culture, body-fluid culture and leukocyte counts were used to assess the conditions and prognosis of patients with sepsis, but the parameters had poor specificity and clinically limited application [5]. The blood lactate acid level is an important biomarker for hypoperfusion and hypoxia in tissues, with more severe hypoxia indicating higher blood lactate acid level. In addition, procalcitonin, a hormonally inactive glycoprotein, is hardly detected in normal health human, and its concentration increases significantly when the patient is in a critically ill condition [6, 7]. Monitoring of blood lactate acid and procalcitonin levels has been reported to play a crucial role in assessing the severity and prognosis of critically ill patients [8, 9]. Nevertheless, the application value of the blood lactic acid procalcitonin levels in the patients with sepsis is still unclear. Consequently, in the present study, we explored the role that detection of the blood lactic acid and procalcitonin levels played in

Table 1. Basic data of the patients

Variable	Survival control group	Death group
Case (n)	46	24
Age (year)	60.3±4.2	63.7±5.1
Gender (male/female)	20/26	12/12
Etiology		
Pulmonary infection	31	15
Abdominal infection	5	3
Skin and soft tissue infection	4	3
Chest infection	4	2
Urinary infection	2	1
Time to onset	5.5±1.6	5.9±1.8

assessing prognosis of patients with septic shock, which lent support to better guidance in the treatment of the patients with sepsis.

Materials and methods

Participants

All the participants in the present study provided written informed consent, and approval of the study protocol was obtained from the Hospital Ethics Committee of our hospital. From January 2014 through December 2016, a retrospective analysis was conducted on 70 patients with confirmed septic shock admitted to the intensive care units in our hospital. The participants included 32 males and 38 females, with an average age of 62.5±4.7 years and a mean disease course of (5.7±1.9) h. Of the 70 patients, 46 had infection from the lung, 7 from skin soft tissue, 6 from the thoracic cavity, and 3 from the urinary tract. The patients were assigned to the survival control group and the death group according to the end point of death or improvement after post-treatment discharge. The patients who were older than 18 years of age were eligible for inclusion if their diagnostic procedures and treatment protocol were in line with the International Guidelines for Management of Severe Sepsis and Septic Shock and they received standard treatment [10-12]. The patients were excluded from the study if they had comorbidities of severe liver and kidney dysfunction, cardio and cerebrovascular disease and blood system disease, a renal replacement therapy; non-infected shock; malignant tumor or diabetes, or withdrew from treatment during the study.

Data collection

The data collected from the patients were as follows: basic data of patients, including age, sex, mean time to onset, source of infection, etiology, and underlying diseases; the blood lactate acid levels which were defined as the blood lactate acid values obtained from all the patients at 0 h, 6 h and 24 h after admission to the ICU, respectively; the procalcitonin levels which were defined as the procalcitonin values obtained from all the patients at 0 h, 6 h and 24 h after admission to the ICU, respectively; the APACHE II scores which were pooledand calculated within 24 h after septic shock had been confirmed.

Outcome measures

The correlations of the bold lactic acid, procalcitonin levels and the APACHE II score with prognosis, as well as the bold lactic acid and procalcitonin levels with the APACHE II score were analyzed among the patients in the two groups.

Statistical analysis

All the statistical data were analyzed using the SPSS software, version 20.0. Measurement data were represented as mean ± standard deviation ($\bar{x}$±s); the comparisons between the groups were made by the t-test, and the comparisons within the same group in the blood lactic acid and procalcitonin levels at different time points were conducted with the use of the repeated measures analysis of variance. Count data were represented as percentages, and the comparisons betweeh the groups were made with the chi square test. Pearson correlation analysis was utilized for detection of the prognostic correlations and APACHE II score correlations. The receiver operating characteristics (ROC) curves were established to assess the significance of the blood lactate acid and procalcitonin levels in prediction of the prognosis of septic shock based on the area under the curves. A *P* value of less than 0.05 was considered statistically significant.

Results

Basic data

There were 46 patients in the survival control group and 24 in the death group. The differ-

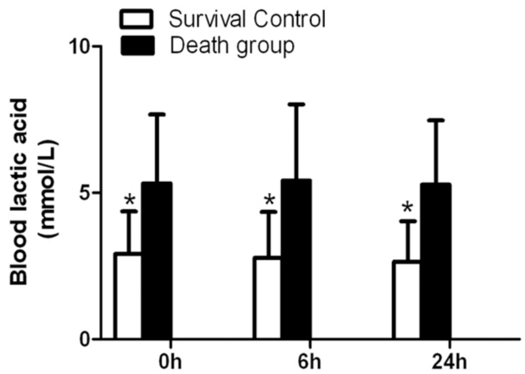

Figure 1. Comparison of the blood lactate acid levels of patients at different time points between the two groups. *P<0.05 for concurrent comparisons with the death group.

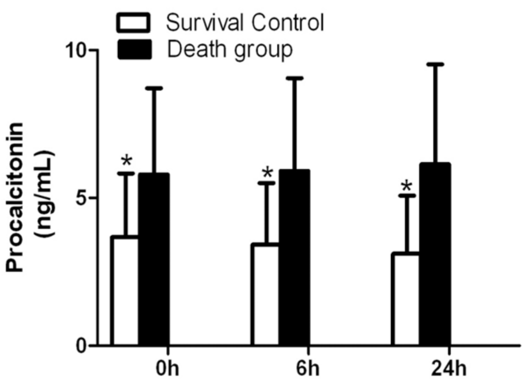

Figure 2. Comparison of the procalcitonin levels of patients at different time points between the two groups. *P<0.05 for concurrent comparisons with the death group.

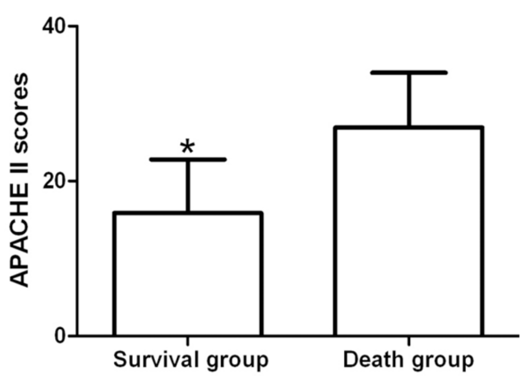

Figure 3. Comparison of the APACHE II scores of patients between the two groups. *P=0.000 for concurrent comparisons with the death group.

ences between the two groups in the basic data including age, sex, etiology and the time to

Table 2. The correlations of prognosis with the blood lactic acid, procalcitonin levels, and the APACHE II scores on the Pearson correlations analysis

Indicator	Correlation coefficient	*P* value
Blood lactic acid	-0.71	0.014
Procalcitonin	-0.84	0.019
APACHE II score	-0.74	0.009

Table 3. The correlations of the blood lactic acid, procalcitonin levels with the APACHE II scores on the Pearson correlations analysis

Indicator	Correlation coefficient	*P* value
Blood lactic acid	0.68	0.006
Procalcitonin	0.77	0.012

symptom onset were statistically insignificant (P>0.05), so they were comparable (**Table 1**).

Blood lactate acid and procalcitonin levels

The blood lactic acid and procalcitonin levels of patients at 0 h, 6 h and 24 h after admission to the ICU respectively were significantly lower among the patients in the survival control group than those in the death group (All P=0.000). The blood lactic acid levels (P=0.002) and the procalcitonin levels (P=0.001) of patients at 0 h, 6 h and 24 h respectively after admission to the ICU showed a dropping trend over time among the patients in the survival control group, where as insignificantly reduced blood lactic acid levels (P=0.083) but rising procalcitonin levels (P=0.007) were observed among those in the death group (**Figures 1**, **2**).

APACHE II score

The APACHE II score of the patients was 15.87±6.93 in the survival control group, and 26.93±7.06 in the death group, with significant difference in the scores between the two groups (P=0.000, **Figure 3**).

Correlations analysis of the various factors

The prognosis of the patients was negatively correlated with the blood lactate acid and procalcitonin levels, and the APACHE II scores (P<0.05) whereas the APACHE II score was positively correlated with the procalcitonin and blood lactate acid levels (**Tables 2**, **3**). The results of the ROC curve analysis on prediction

Table 4. Prediction of death among the patients with septic shock based on the blood lactate acid and procalcitonin levels on the ROC curves

Indicator	Area under the curve	Standard error	*P* value	95% CI
Blood lactic acid (mmol/L)	0.529	0.067	0.013	0.463-0.675
Procalcitonin (ng/mL)	0.611	0.072	0.009	0.662-0.912

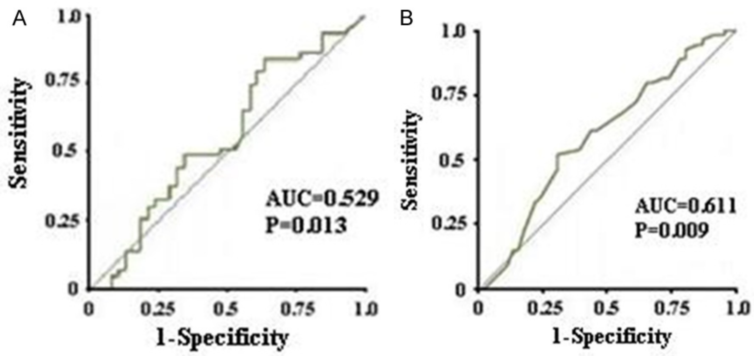

Figure 4. Prediction of death among the patients with septic shock based on the blood lactate acid and procalcitonin levels on the ROC curves. A: Blood lactate acid; B: Procalcitonin.

of death among patients with septic shock based on the blood lactate and procalcitonin indicators revealed that the blood lactate acid and procalcitonin levels were predictive of prognosis of the patients with septic shock, and there was significant difference (P<0.05, **Table 4** and **Figure 4**).

Discussion

Septic shock is a clinical complication with high mortality caused by the worsening health conditions in patients with sepsis, primarilyas the result of the interactions between bacterial infection and immune defense mechanisms. Currently, although growing advances have made in medical treatment, the mortality of septic shock remains high. Therefore, assessment of the severity of sepsis in the patients encourages early intervention in a timely manner, reducing the mortality of the patients.

The APACHE II score is one of the measures for assessing the severity of diseases in critically ill patients, and is extensively used in clinical practice. Monitoring the APACHE II score can not only assess the patient's conditions, but also predict the mortality of the patients [13]. The results of the present study demonstrated that the mean APACHE II score (15.87±6.93) in the survival control group was significantly lower than that (26.93±7.06) in the death group (P<0.05). Moreover, the APACHE II score was negatively correlated with the prognosis of patients, with lower APACHE II scores indicating better prognosis. This may be due to the fact that the APACHE II score is involved in a sea of clinically physiological and laboratory indicators, and the patients with septic shock frequently have a variety of underlying diseases, leading to hypoxia, acidosis, andelectrolyte disturbances. All these are associated with the abnormality in the indicators, and concurrently suggest that more severe organ dysfunction indicates worse prognosis. The results were basically similar to those in the previous reports [14].

Procalcitonin is a calcitonin precursor substance that is synthesized and secreted by thyroid C cells [15]. A study suggested that trauma, medullary thyroid carcinoma, burns, and early postoperative development are associated with elevated procalcitonin levels [16]. Multiple studies worldwide have shown that procalcitonin can effectively induce the effect of ant-infection in critically ill patients [17, 18]. Besides, procalcitonin can be used as an early indicator for the diagnosis and assessment of bacterial infectious diseases. The present study found that, as compared tothe death group, the procalcitonin levels decreased significantly among the patients in the survival control group; over time, the procalcitonin showed a dropping trend; in addition, the procalcitonin level was negatively correlated with prognosis of the patients, but positively correlated with the APACHE II score. It suggests higher procalcitonin level indicating worse prognosis, which is consistent with that reported in previous literature [19].

Lactic acid is a product of anaerobic metabolism in the body. The blood lactate acid level is a biomarker of organ function and energy metabolism, which is related to prognosis and mortality of the patients [20]. Lactic acid is mainly produced by striated muscle, erythrocytes and brain tissue, and the degree of its changes in plasma depends on the metabolic rate of liver and kidney in patients [21]. In patients with sepsis, the presence of hypoperfusion and hypoxia in the tissues is associated with oxygen supply insufficient for metabolism, resulting in a significant elevation in the blood lactate acid level. With the progression of the disease, septic shock develops in the patients, when the clearance of lactic acid in the liver is greatly weakened, there by leading to a further rise in the blood lactic acid level. Noticeably, monitoring the changes in the blood lactic acid level is in favor of assessment of prognosis in patients with sepsis. Ourpresent study revealed that the blood lactic acid level decreased substantially and showed a dropping trend among the patients in the survival control group as compared with those in the death group; the blood lactic acid level was negatively correlated with the prognosis of the patients but positively correlated with APACHE II score, which were consistent with the previous reports [22]. The blood lactate acid and procalcitonin levels predicting the mortality of patients with septic shock on the ROC curves showed the areas under the curves of greater than 0.5, with significant differences. In the present study, the area under the curve was calculated as including the blood lactate acid and procalcitonin levels of all patients, bur no subgroup analysis was performed. Future experiments are needed to analyze the predictive value of the blood lactate acid and procalcitonin levels across the subgroups.

In conclusion, monitoring of the blood lactate acid and procalcitonin levels plays an important role in assessing the severity, efficacy, and prognosis of septic shock. In the future, further studies with larger sample size are expected to provide experimental and theoretical foundation for the treatment of septic shock.

Disclosure of conflict of interest

None.

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