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Comparison of serum lactate and base excess in predicting the survival outcome in polytrauma patients

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Abstract

Aims: To determine the earlier and better prognostic marker between 'blood lactate levels' and base excess' in polytrauma patients. Additionally we sought to determine the effect of lactate normalisation time on outcome.

Materials and Methods: This is a prospective, non-interventional study conducted at our trauma centre after approval from our institutional ethical committee involving 60 polytrauma cases. Revised Trauma Score (RTS) and Injury Severity Score (ISS) on admission were calculated. Arterial blood samples for serum lactate and base excess levels at admission, every 12hours within first 48h after admission and one sample on third day were collected.

All continuous variables were expressed as mean ± standard deviation. They were compared using Student's t-test and Analysis of Covariance. Ability of individual variables in predicting mortality at different time points were compared using Receiver operating characteristic curves (ROC curves).Time to lactate clearance was analysed with outcome using chi-square for trend.

Results: Serum lactate levels on admission were significantly different in non survivors compared to survivors (p=0.006). Base excess at 24 hours was significantly different in non survivors compared to survivors (p =0.012). Serum lactate at 24 h predicted mortality better [Area under the curve(AUC) 0.95 (Confidence interval(CI) -0.86 to 0.99)], than base excess at 24 h [AUC 0.72 (CI-0.59 to 0.83)], p<0.001. Time taken for lactate to normalise ≤24 h, 25-48 h and >48 h were associated with mortality of 0%, 30% and 96% respectively.

Conclusions: Serum lactate is an early predictor of outcome compared to base excess. Patients with lactate normalisation time within 48 h had better outcome.

Keywords: Serum lactate levels, Polytrauma, Predictive

Introduction

Lactate is often considered a measure of tissue hypoxia. Although lactate can be elevated in non-hypoxic situations such as pyruvate dehydrogenase deficiency, liver and renal dysfunction, the utility of guiding resuscitation by lactate clearance has been validated by studies.[1,2,3]

The time to clear or normalize the lactate level appears to be strongly predictive of mortality when compared to elevated lactate. Marie-Alix Régnier et al[1] in their study stated that lactate clearance within two hours of admission was a better prognostic predictor when compared to single lactate value or other factors. The main advantages of monitoring blood lactate concentration as an indicator of metabolic derangements include sensitive, accurate information about tissue perfusion and oxygen debt, simple performance and rapid availability of results.

Base excess has been a marker of mortality in many studies.[4,5,6] Furthermore, changes in the base excess will often precede changes in other hemodynamic parameters in haemorrhagic shock. Base excess can be elevated in many other situations such as diabetic ketoacidosis, salicylate overdose, and renal dysfunction. Early identification of patients with tissue hypoxia would enable better triage decisions to be made with regard to further management.

Our study aimed at identifying the better prognostic marker amongst base excess and lactate in polytrauma patients.

Methods

This is a prospective, non-interventional study conducted at our trauma centre after approval from our institutional ethical committee.

Sixty patients admitted into emergency department within six hours of polytrauma over a period of one year were included. Minimum sample size required was determined to detect a significant difference in the outcome between the mean lactate at 24 hours after admission the two groups at 5% significance level with a statistical power of 80%.

Polytrauma patients admitted within six hours of trauma, patients aged between 20-40 years following polytrauma were included.

Patients with Diabetes mellitus, ischemic heart disease, congestive heart failure, renal failure and liver dysfunction were excluded from the study based on history and clinical findings.

Blood pressure (BP), Glasgow coma scale (GCS), Respiratory rate (RR) were recorded on admission. Revised Trauma score (RTS) on admission was calculated as follows:

Revised Trauma score[7] = 0.9368 GCS + 0.7326 SBP + 0.2908 RR

Normal Values for the Revised Trauma score are in the range 0 to 7.840

Injury Severity Score is an anatomical scoring system that provides an overall score for patients with multiple injuries. Each injury is assigned an Abbreviated Injury Scale (AIS) score, allocated to one of six body regions (Head, Face, Chest, Abdomen, Extremities (including Pelvis), and External). Only the highest Abbreviated Injury Scale score in each body region is used. The three most severely injured body regions have their score squared and added together to produce the Injury Severity Score.

Blood lactate and base excess levels were estimated from arterial blood sample at admission, every 12h within first 48h after admission and one sample on third day. These samples were collected based on institutional protocols.

The analysis of plasma lactate and base excess was carried out by Gem Premier 3000 blood gas instrument.

Statistical analysis: All continuous variables were expressed as mean ± standard deviation. They were compared using student's t-test and Analysis of Covariance (ANCOVA) where applicable. Ability of individual variables in predicting mortality at different time points were compared using Receiver operating characteristic curves (ROC curves).Time to lactate clearance was analysed with outcome using chi-square for trend. Statistical analysis was done on MEDCALC SOFTWARE 11.4.

Results

Sixty polytrauma cases admitted in emergency department were included in the study of which 30 were survivors and 30 were non-survivors. The mean age in survivors was 32.1±8.6 years and non-survivors was 31.6±7.9 years. There were 19 males and 11 females in survivors and 20 males and 10 females in non survivors (P =0.79, Fisher's Exact Test). Revised Trauma Scores of survivors and non-survivors were compared, the difference was found to be significant (P =0.003). Similar result was found when Injury Severity Scores were compared (P=0.005).

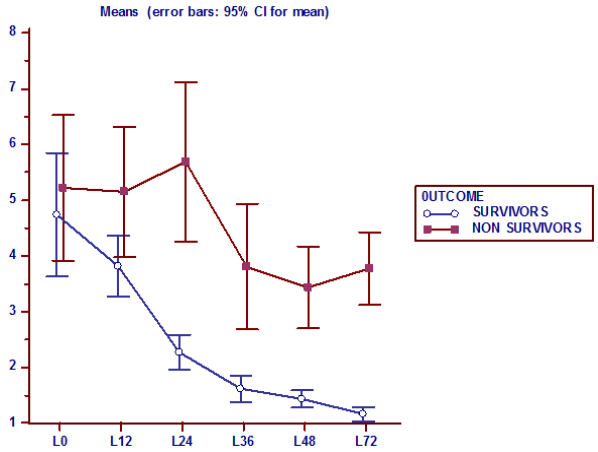

Fig. 1: Lactate Levels

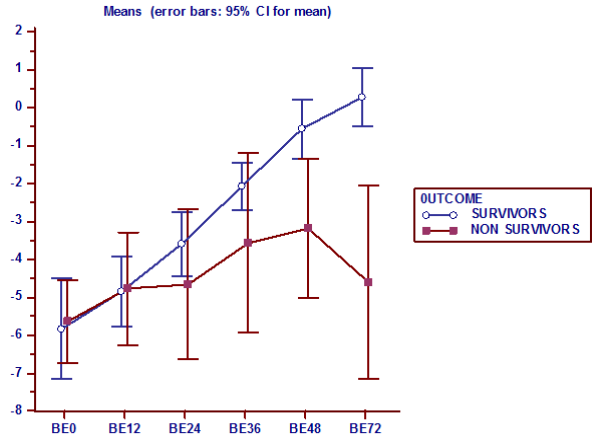

Fig. 2: Base excess levels

Serum Lactate levels amongst survivors and non survivors at different time points were compared and it was found that lactate levels from 12h time point were significantly higher in non survivors when compared survivors (P<0.001), whereas base excess levels were significantly higher (P<0.001) after 36h. Mean serum lactate levels at admission were different between survivors and non survivors (4.74 ± 2.94 versus 7.27 ± 3.90; P=0.006). At the end of 24 hours after admission, the mean serum lactate levels normalized among survivors (2.27 ± 0.83), whereas among non survivors the mean serum lactate levels continued to remain high (6.23 ±2.47). The difference in mean serum lactate levels in the survivors and non survivors at 24 hours after admission was significantly different (P<0.001). Predictive ability of Lactate and Base excess was determined by Receiver operating characteristic (ROC) curves (Table 1, 2).

Predictive ability of Lactate (Table 1)

Table 1

Lactate (Hours)	Area Under Curve (AUC)	95% Confidence Interval (CI)
L0	0.565	0.412 to 0.709
L12	0.665	0.512 to 0.796
L24	0.916	0.797 to 0.977
L36	0.925	0.809 to 0.981
L48	0.937	0.826 to 0.987
L72	0987	0.901 to 1.000

Predictive ability of base excess (Table 2)

Table 2

Base Excess (Hours)	Area Under Curve (AUC)	95 % Confidence Interval (CI)
BE0	0.527	0.377 to 0.675
BE12	0.526	0.376 to 0.674
BE24	0.584	0.431 to 0.726
BE36	0.632	0.479 to 0.768
BE48	0.690	0.539 to 0.817
BE72	0.835	0.698 to 0.927

Lactates had predictive ability of outcome as early as 24h (>3mmol/L) [AUC 0.916 (CI 0.79-0.97) P<0.0001]. Base excess (≤-3.8mmol/L) had predictability after 72h [AUC 0.835 (CI-0.69 to 0.92), P<0.0001]. Lactate at 24 h had better predictability [AUC 0.95 (CI-0.86 to 0.99)] than base excess at 24h [AUC 0.72 (CI-0.59 to 0.83)].

Table 3

Duration (Hours)	Area Under Curve (AUC)	95% Confidence Interval (CI)
L24	0.952	0.864 to 0.991
BE24	0.722	0.591 to 0.830

P<0.001(Table 3).

Time taken for lactate to normalise was analysed with outcome using chi-square for trend 9.6(P=0.001) (Table 4).

Table 4

Lactate Clearance Time (Hours) (Total Number of patients in each category)	Martality (%) (Number of Non-survivors)
<24(15)	0(0)
25-48(20)	30(6)
>48(25)	96(24)

Lactate and base excess at admission correlated with trauma scores. The lactate scores at admission had a strong negative correlation with RTS (r=-0.86) and a strong positive correlation with ISS (r=0.87). The base excess at admission had a moderately positive correlation with RTS (0.67) and a moderately negative correlation with ISS (0.59).

Discussion

Polytrauma patients show reduced perfusion and arterial oxygen supply. Inadequate tissue oxygenation is associated with enhanced production of lactate and the resulting increase in blood lactate concentrations. The two most commonly used markers in assessing resuscitation are base excess and Lactate (Lactic acid) as they are easily obtained during resuscitative efforts and results are provided quickly. The main advantages of monitoring blood lactate concentrations as an indicator of metabolic derangements include sensitive, accurate information about tissue perfusion and oxygen debt, simple performance and rapid availability of results. Furthermore, changes in the base excess will often precede changes in other hemodynamic parameters in haemorrhagic shock.

Our study shows that serum lactate and base excess levels were higher in non survivors when compared to survivors. Serum lactate levels on admission were significantly higher in non survivors when compared to survivors (P=0.006). Base excess was also found to be significantly higher in non survivors when compared to survivors at 24 h (P =0.012). In a study conducted by Ouellet et al[8] non survivors displayed higher mean lactate (3.6 vs. 2.2, P < 0.0001), a worse median BD (−10 vs. −5, P <0.0001), and a lower pH (7.23 vs. 7.31, P < 0.0001) at arrival compared with those of survivors.

In our study, ability of the values in predicting the prognosis was analysed using ROC curves. If area under the curve is >0.7 it is a good screening tool, but for predicting the prognosis it is preferable to have area under the curve (AUC) to be >0.9 (more specific). In our study, it was found that serum lactate levels (at 24h AUC 0.91) predicted the outcome earlier when compared to base excess (at 24h AUC 0.58, at 72 h AUC 0.83). Neville et al[9] documented elevated lactate and BD were strong predictors of early mortality (within first 24 hours).

Serum lactate in our study had significant positive correlation (correlation coefficient 0.87) with Injury Severity Score and significant negative correlation (correlation coefficient -0.86) with Revised Trauma Score when compared to base excess, which had a correlation coefficient of -0.59 with Injury Severity Score and correlation coefficient of 0.67 with Revised Trauma Score. Study by Cerović O et al[10] confirmed using linear regression, the relationship between blood lactate levels and injury severity score. They showed that higher lactate concentrations and lower Triage Revised Trauma Score (T-RTS) on admission are associated with higher Injury Severity Score values.

Prolonged lactate normalisation time was associated with higher mortality. Time taken for lactate to normalise was associated with a mortality of 0%, 30% and 96% for ≤24h, 25-48 h and >48h respectively. Thus, showing that serial measurement of arterial serum lactate is a simple and effective predictor of outcome. Nguyen

HB et al,[11] Krishna U et al[12] and Régnier M et al[13] showed that prolongation of lactate clearance is associated with increased mortality. Failure of a patient to normalize lactate is associated with 100% mortality. Studies have also shown that better chances of survival occur when resuscitation efforts result in lactate clearance to normal values in ≤ 24h.[11,12,13]

Contrary to the predominant evidence, a retrospective study done by Freitas A D et al[14] reports lack of correlation between lactate clearance and survival outcomes. Further, the article acknowledges that their results are at variance from other published literature, but apart from sample size of 117, which they say is low, they do not put forward any clear explanation as to why they could not observe any correlation. Other possibility for the difference in results between our study and Freitas A D et al[14] study may be due to methodological differences in inclusion/exclusion criteria (Diabetes Mellitus, Ischemic heart disease, renal or liver dysfunction which influence lactate clearance)[15] or patient management protocols.

To conclude, serial lactate levels are better predictors of outcome in patients of polytrauma when compared to base excess. Early lactate normalisation improves the outcome in polytrauma patients. Every patient of polytrauma should have arterial blood gas analysis. The ability to obtain from this one measurement, a reliable indicator of prognosis, would thus aid decision making process.

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