The Journal of Emergency Medicine, Vol. 48, No. 6, pp. 693–698, 2015

0736-4679/$ - see front matter

ELSEVIER

http://dx.doi.org/10.1016/j.jemermed.2014.12.081

Selected Topics: Critical Care

DETERMINING THE UTILITY OF METABOLIC ACIDOSIS FOR TRAUMA PATIENTS IN THE EMERGENCY DEPARTMENT

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☐ **Abstract—Background: Metabolic acidosis has been proposed as the gold standard to define shock in trauma patients. Other studies determine the presence of shock by use of serum lactate. However, not all medical centers have the ability to utilize point-of-care lactate at bedside. Objective: This study seeks to determine the relationship between serum lactate and metabolic acidemia in trauma patients, and if metabolic acidemia can be used to guide therapy. We hypothesized that acidemia would be strongly correlated with lactate levels and would be associated with activation of massive transfusion (MT) in the presence of shock in trauma. Methods: This was a prospective observational cohort study, level II evidence; this study aids in decision-making. Setting was a Level I academic, urban trauma center. The study took place from July 1, 2012 to March 1, 2013 and included patients who were ≥18 years old and required trauma team activation. Observations included baseline demographics (age, gender, type of injury), vital signs, point-of-care arterial blood gas, lactate, and need for MT. Results: One hundred patients were enrolled over the study period. The average age was 34 years, and 82% were male. Forty patients were acidemic (pH < 7.35), and there was a significant difference in lactate levels between the acidemic and non-acidemic groups ($p < 0.002$). We found a strong correlation between pH and lactate: $r_s = -0.38$, $t = -4.03$, $p < 0.001$. In addition, using a logistic regression, we show that pH was associated with activation of MT ($p = 0.002$). Conclusion: This is a prospective observational cohort study with level II evidence. This study demonstrates that acidemia was strongly correlated to serum lactate, lactate levels were higher in the acidemic group, and metabolic acidemia was associated with the activation of MT for trauma patients at our institution.** © 2015 Elsevier Inc.

☐ **Keywords—pH; lactate; massive transfusion; trauma; metabolic acidemia**

This study has been presented as a poster at annual meeting of New York American College of Emergency Physicians (NYACEP) 2013, and American College of Emergency Physicians (ACEP) 2013.

INTRODUCTION

Hemorrhagic shock is one of the leading causes of mortality in patients suffering from trauma (1). Appearance, vital signs, laboratory results (i.e., biomarkers such as serum lactate), and imaging are all factors that play a role in detecting shock during the evaluation of trauma patients. Accurate interpretation of this information must be quick, but is not always easy. There exists a need for reliable evidence to evaluate a patient's status to optimize treatment.

Treatment of hemorrhagic shock using damage control resuscitation is a two-part process by which the physician stops the bleeding and gives fluids/blood products to restore normal physiologic parameters. The process becomes less efficacious the more it is delayed. Metabolic

RECEIVED: 24 April 2014; FINAL SUBMISSION RECEIVED: 10 November 2014;
ACCEPTED: 21 December 2014

acidosis has been proposed as the gold standard to define shock in trauma patients. Other studies determine the presence of shock by use of serum lactate (2,3). There is a significant increase in mortality when lactate levels exceed 4 mmol/L (4,5). However, not all emergency departments (EDs) have access to point-of-care lactate.

This study aimed to determine the relationship between serum lactate and metabolic acidemia in trauma patients, and to evaluate the association of acidemia with the activation of massive transfusion protocol (MT) at our institution. We hypothesized that acidemia would be correlated with lactate levels and would be associated with the use of MT.

MATERIALS AND METHODS

We conducted a prospective observational cohort study at a Level I urban trauma center from July 1, 2012 to March 1, 2013. Our institutional review board approved this study (IRB# 12-029). We included any patient presenting to the ED for blunt or penetrating trauma requiring trauma team activation as recommended by the American College of Surgeons Committee on Trauma, ≥18 years of age, not intubated in the field, who did not receive blood products, or who received <1 L of fluids prior to obtaining blood samples. We excluded any patient in traumatic arrest, intubated in the field, <18 years of age, who received blood products, or who received >1 L of fluid prior to blood draw. Study investigators and the departmental research assistant enrolled patients in the study.

We calculated a convenience sample size of n = 100, a priori, to achieve a power of 0.8 with a probability of a type I error set at 0.05 based on calculating a Spearman rank correlation with a magnitude of 0.7 for the primary outcome. We enrolled patients 24 h a day during the study period. We identified patients based on prehospital identification and need for trauma team activation.

On presentation, we obtained baseline demographics (age, gender, type of injury), vital signs (blood pressure, heart rate, respiratory rate, oxygen saturation), point-of-care arterial blood gas (ABG), and lactate. We then followed patients to determine the need for MT. The guidelines set forth by the hospital's interdisciplinary transfusion committee determined when to activate massive transfusion, which utilizes the ABC score (Table 1).

The Massive Transfusion Protocol may only be activated by an order from an attending physician or designee and should meet at least two of the four indications listed below.

A. Evidence of an acute hemorrhage
   a. Systolic blood pressure ≤ 90 mm Hg
   b. Heart rate ≥ 120 beats/min
   c. Penetrating mechanism
   d. Positive fluid on focused assessment with sonography for trauma or utilization of three units of packed red blood cells from trauma room refrigerator without restoration of normal vital signs.
B. Evidence of a significant metabolic acidosis/shock with base deficit of ≤ −5
C. Evidence of coagulopathy: international normalized ratio ≥ 1.5
D. Evidence of hypoperfusion: lactate ≥ 4.0

Physicians were not blinded to laboratory results, however, it is important to note that pH is not taken into consideration in the ABC score.

A Spearman rank-based correlation determined the relationship between pH and lactate, as lactate is not normally distributed with normal values <2 mmol/L. A Student's *t*-test compared the lactate level in acidemic vs. nonacidemic patients (acidemia was defined as pH < 7.35). Finally, we used a binary logistic regression to determine if either pH or lactate level was associated with activation of MT. For statistical calculations, we used Excel and "R". We did not include values >2.5 standard deviations in the study. p Values were two-tailed.

RESULTS

Over the study period, 909 patients presented for trauma, of which the trauma team was activated for 252 cases. From these cases, 112 patients were eligible for enrollment, and 100 were enrolled in our study (Figure 1).

The average age was 34 years, and 89% were male. Fifty-three percent suffered blunt trauma. Table 2 shows the baseline demographics of the cohort. Forty patients were acidemic. The injury severity score (ISS) was 15.2 (95% confidence interval [CI] 10.5–19.8) for acidemic patients and 14.7 (95% CI 10.7–18.5) for nonacidemic patients.

There was a strong correlation between pH and lactate: $r_s = -0.38$, t = −4.03, $p < 0.001$ (Figure 2).

Lactate levels were significantly different between the two groups: 6.18 mmol/L (95% CI 4.4–7.7) in the acidemic group vs. 3.31 mmol/L (95% CI 2.8–3.7) in the nonacidemic group ($p < 0.002$). A greater percentage of acidemic patients received MT compared to those who were not acidemic (22.5% vs.13.3%, respectively).

Lastly, using a logistic regression, Table 3 shows that pH, in addition to lactate, was associated with activation of MT ($p = 0.002$ vs. $p = 0.001$, respectively).

DISCUSSION

The clinical approach to trauma patients involves early identification of significant hemorrhaging and addressing