Annals of Medicine and Surgery 10 (2016) 41–48

Contents lists available at ScienceDirect

Annals of Medicine and Surgery

journal homepage: www.annalsjournal.com

The use of finger-stick blood to assess lactate in critically ill surgical patients☆

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HIGHLIGHTS

- Finger-stick capillary lactate correlates with blood gas and core lab values.
- Capillary lactate trends closely over time with arterial lactate.
- Rising or falling capillary lactate reflects the adequacy of global perfusion.
- Capillary lactate measurements require a fraction of the time and blood to process.
- Preliminary results imply capillary lactate may be used in lieu of invasive methods.

ARTICLE INFO

Article history:
Received 2 April 2016
Received in revised form
23 July 2016
Accepted 24 July 2016

Keywords:
Capillary lactate
Finger-stick
Point-of-care
Shock

ABSTRACT

Background: Using finger-stick capillary blood to assess lactate from the microcirculation may have utility in treating critically ill patients. Our goals were to determine how finger-stick capillary lactate correlates with arterial lactate levels in patients from the surgical intensive care unit, and to compare how capillary and arterial lactate trend over time in patients undergoing resuscitation for shock.

Methods: Capillary whole blood specimens were obtained from finger-sticks using a lancet, and assessed for lactate via a handheld point-of-care device as part of an "investigational use only" study. Comparison was made to arterial blood specimens that were assessed for lactate by standard laboratory reference methods.

Results: 40 patients (mean age 68, mean APACHEII 18, vasopressor use 62%) were included. The correlation between capillary and arterial lactate levels was 0.94 ($p < 0.001$). Capillary lactate measured slightly higher on average than paired arterial values, with a mean difference 0.99 mmol/L. In patients being resuscitated for septic and hemorrhagic shock, capillary and arterial lactate trended closely over time: rising, peaking, and falling in tandem. Clearance of capillary and arterial lactate mirrored clinical improvement, normalizing in all patients except two that expired.

Conclusion: Finger-stick capillary lactate both correlates and trends closely with arterial lactate in critically ill surgical patients, undergoing resuscitation for shock.

1. Introduction

Lactate is a principal biomarker used in the assessment and treatment of critically ill patients. Traditionally measured from arterial blood, lactate is generated in states of oxygen deprivation via reduction of pyruvate by lactate dehydrogenase. This lactate is cleared by the liver, kidneys, and heart. In the liver, lactate enters the Cori cycle to become glucose [1]. Under homeostatic conditions, lactate levels are usually below 2 mmol/L as clearance matches production. Under conditions of physiological stress and

Abbreviations used: ICU, intensive care unit; POC, point-of-care; BGA, blood gas analyzer; CL, core lab.

☆ Presented at the Society of Critical Care Medicine, San Francisco on January 10, 2014, and at the Surgical Infection Society, Baltimore, Maryland on May 3, 2014.

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http://dx.doi.org/10.1016/j.amsu.2016.07.021

pathological conditions, plasma lactate levels may rise above 2 mmol/L as production overwhelms clearance. As such, lactate rise secondary to inadequate oxygen delivery is an early sign of shock [1].

Initial lactate levels help risk-stratify patients for triage in the pre-hospital, emergency room, ward, and intensive care unit (ICU) environments [2–4]. Greater elevation and duration of lactic acidosis correlate with worse prognosis [1]. In contrast, clearance of lactate over time correlates with improved survival, and helps guide resuscitation protocols in shock [2,5–7].

Finger-stick capillary lactate is being evaluated as an alternative to arterial lactate testing in the care of critically ill patients. Growing interest in the application of capillary lactate has come with the development of handheld point-of-care (POC) devices that incorporate test strip technology similar to that of glucometers. These POC devices can process tiny microliter aliquots of capillary blood from patient finger-sticks, with rapid result turnaround time at the bedside.

The use of capillary lactate may have several advantages. Sampling of finger-stick capillary blood avoids the need for arterial and venous puncture, indwelling catheters, and large volume blood draws. Results are obtained within seconds and transport of specimens to the lab is eliminated, with demonstrated timesaving of greater than 1 h [8]. Using capillary lactate might enable the earlier identification and triage of patients with lactic acidosis. In addition, trending serial capillary lactate checks over time could help to guide resuscitation in a dynamic fashion.

Individual capillary lactate measurements have been shown to correlate with arterial lactate measurements in patients from both the emergency room and medical ICU populations [8,9]. However, further study is needed in surgical patients in whom the application of capillary lactate could be particularly beneficial, in such areas as triage, monitoring, and shock resuscitation. The correlation of capillary and arterial lactate levels in surgical patients has yet to be determined. In addition, the way in which capillary and arterial lactate levels together trend over time in a single patient, and the effect of vasopressors on capillary lactate in critically ill patients undergoing resuscitation has never been assessed. In this paper, we show for the first time that the trend of capillary and arterial lactate levels correlate over time, suggesting that capillary lactate can be used to monitor resuscitation and treatment for shock.

Table 1
Patient demographics.

Patient demographics	Number	Percent
Number of patients	40	
Male:Female	17:23	
Mean Age (years)	68	
Underlying Diseases		
Hypertension	23	58%
Diabetes	13	33%
Severity of Illness		
Mean APACHE II	18	
Vasopressors	25	63%
Types of Shock		
Septic	16	40%
Hypovolemic	8	20%
Cardiogenic	1	3%
Types of Cases		
General Surgery	29	72%
Vascular	4	10%
Urology	2	5%
Head Neck	2	5%
Neurosurgery	2	5%
Gynecology	1	3%

2. Methods

The study took place in the surgical intensive care unit of an 800 bed urban teaching hospital, from September 2013 until February 2014. The hospital's Institutional Review Board for human research approved the study protocol with waiver of consent (IRB #052-13). Patients were included if they were undergoing active resuscitation for shock. Most had either septic or hypovolemic shock as defined by standard criteria [7].

POC analysis was performed using a handheld POC lactate analyzer (StatStrip, Nova Biomedical Corporation, Waltham, MA), which has a 0.6 μl sample size, has a detection range 0.3 mmol/L to 20 mmol/L, and provides results in 13 s. This POC lactate analyzer is Clinical Laboratory Improvement Amendments approved for POC measurement of fresh venous and arterial whole blood specimens; assessment of capillary lactate was part of an "investigational use only" study. The analyzer uses single-use test strips containing an enzyme-coated electrode. Calibration was assessed every 24 h by using standard test strips with known lactate values.

Finger-stick capillary whole blood was collected every 4–6 h on average, from patients who were undergoing checks for finger-stick whole blood glucose as part of the ICU's glucose-control protocol. As part of this protocol, the fingertip was cleaned with 70% isopropyl alcohol and allowed to air dry. A drop of capillary blood was obtained by using a single-use disposable lancet (Roche Accu-Chek, Basel, Switzerland) to pierce the side of the fingertip. A small aliquot of this blood was transferred to the handheld POC lactate analyzer to assess capillary lactate level, with the remainder of the drop being transferred to the glucometer; consequently, no additional blood was required for the study, beyond that already being drawn as part of the ICU's standard operating procedure. Capillary lactate results were not reported to any physicians caring for the patients, nor used to guide clinical decisions.

Arterial blood specimens were drawn according to the clinical discretion of the ICU team, from indwelling arterial lines, and collected into either 3 ml heparinized-arterial blood sampling syringes (Smiths Medical, Keene, NH), or 4 ml grey-top Vacutainer tubes (BD, Franklin Lakes, NJ) placed on ice. The arterial blood was assessed for lactate by standard reference methods including a blood gas analyzer (BGA) (Premier 3500, Instrumentation Laboratory Co., Bedford, MA), and core lab (CL) (VITROS 5.1, Ortho-Clinical Diagnostics, Raritan, NJ). The BGA and CL were calibrated and maintained according to manufacturer standards.

Comparison was made retrospectively between capillary and arterial lactate results that had been drawn close in time, with values recorded within 10 min of each other. Correlation between capillary and arterial lactate was determined by simple linear regression using each value as a variable. The strength of association between the variables was measured by the Pearson correlation coefficient, with a p-value < 0.05 being considered statistically significant. Analysis of agreement was performed using the Bland-Altman method accounting for repeated measurements per individual [10]. Statistical data analysis was performed using Microsoft Excel for Mac 2011 (Redmond, WA), and MedCalc for Windows (MedCalc, Ostend, Belgium). Capillary and arterial lactate trending curves were created using Microsoft Excel for MAC 2011 (Redmond, WA).

3. Results

A convenience sample of 40 patients was included from June 2013 until February 2014. Patient demographics are shown in Table 1. The mean age was 68 years and the mean APACHE II score was 18. Sixty-two percent of patients were on vasopressors and in shock.