Blood Lactate Determined by a Portable Device in Critically Ill Patients

CHAIRAT PERMPIKUL, M.D.*,
RANISTHA RATANARAT, M.D.*,
NEELOBOL NEUNGTON, M.D.**

Abstract

Patients with tissue perfusion deficit usually have lactic acidosis or hyperlactacidemia and blood lactate level has been used to diagnose this condition and to monitor the disease progression. We conducted a study to examine the diagnostic accuracy of capillary and arterial lactate (C LAC and strip A LAC) obtained by using a portable lactate analyzer (Accusport ®) compared with the standard method (A LAC) in this condition. Forty eight patients were included in the study. Strong correlation between C LAC and A LAC as well as strip A LAC and A LAC were demonstrated ($r = 0.89$ and 0.98 respectively, $p < 0.05$). When determining agreement between C LAC and strip A LAC with the standard method, all but 2 of C LAC – A LAC differences and 2 of strip A LAC – A LAC differences were within the agreement limits (mean ± 2SD). We conclude that capillary and arterial lactate determined by the tested device, when used and interpreted cautiously, can substitute arterial lactate in the diagnosis of hyperlactacidemia and monitoring the effectiveness of therapy.

Key word : Lactate, Lactate Determination, Portable Lactate Analyzer, Critically Ill Patients

PERMPIKUL C, RATANARAT R, NEUNGTON N
J Med Assoc Thai 2000; 83: 1348-1353

Lactate is the end product of the anaerobic metabolism of glucose and its accumulation in the blood signals an increase in production or a decrease in utilization or both. When carefully interpreted, arterial lactate proves to be a good marker for inadequate supply or utilization of oxygen in tissue[1-5]. In patients with septic shock, high arterial lactate level indicates poor tissue perfusion and serial studies can be used to monitor the effectiveness of shock therapy[4]. Lactate level was also reported to be a good predictor of survival in patients with multiple trauma[3,5].

In clinical practice, however, there are limitations in obtaining lactate level since the

* Department of Medicine,
** Department of Biochemistry, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

standard method for lactate determination requires multiple time consuming processes from specimen collection and transportation to biochemical laboratories. In certain areas, such as in Thailand, significant time lag between blood collection and laboratory report makes the results not clinically applicable. If there is an alternate method for blood lactate determination which is reliable and can be more rapidly and easily performed than the standard method, it would be very convenient and useful.

Recently, a simple quantitative test for capillary lactate (Accusport R) was developed and used in sport medicine. This method can quantify lactate level by using capillary blood applied to a strip attached to a portable device. The process is simple and the result is obtained in 1 minute[6]. We, therefore, examined the quantitative determination of capillary and arterial lactate by using this device in suspected hyperlactacidemic patients.

PATIENTS AND METHOD

Patients

The study population consisted of patients who presented with symptoms suggesting hyperlactacidemia. Upon entering the study, their capillary blood was taken and applied to a test strip which was attached to the reading device. The arterial blood was almost simultaneously taken and a drop was applied to a strip. The rest the of the arterial blood was ice-chilled and transported to the biochemical laboratory for standard lactate determination.

Portable lactate analyzer

The portable lactate analyzer and the disposable test strip (Accusport R) were kindly given by Boehringer Mannheim Co. Lactate was determined by using a small reflectance photometer. Measuring principle is described briefly as follows[7]. When capillary blood is applied on the strip, blood seeps through the yellow protective mesh into a glass fiber fleece where the erythrocytes are retained. Only the plasma reaches the detection film. Lactate, then, is quantitatively determined by reflectance photometry *via* a colorimetric lactate- oxidase mediator reaction. The instrument's range for whole blood lactate analysis is between 0.8-22 mmol/L.

Arterial blood lactate determination

Arterial blood was collected in tubes containing sodium fluoride and was immediately placed on ice and transported to the biochemical laboratory for standard lactate determination by rapid enzymatic measurement method described by Marbach EP et al[8]. The normal range in our laboratory is 1.49 ± 0.6 mmol/L.

Statistical analysis

We expressed our descriptive statistics as mean ± SD. The extent to which capillary blood lactate (C LAC) and strip arterial blood lactate (strip A LAC) could substitute for standard arterial blood lactate (A LAC) were assessed by measures of both correlation and agreement between these values. Correlation between C LAC and A LAC, and between strip A LAC and A LAC were determined by simple linear regression using each value as a variable. The strength of association between the two variables was measured by the Pearson correlation coefficient (r).

Analysis of agreement was performed by using precision-bias matrix as described by Bland and Altman. The method is described as follows (9,10). For each pair of measurements; for example, the capillary - arterial lactate difference (C LAC minus A LAC, Y axis) was plotted against the mean of the A LAC and C LAC values (X axis). The horizontal line labeled "mean" indicates the mean of the C-A differences which is known as the line of agreement. It is bound by two parallel lines, known as the limits of agreement which are drawn at ± 2SDs above and below the line of agreement. We can conclude that the two measurements are in sufficient agreement to allow substitution of C LAC for A LAC in individual patients if C-A difference are within limits of agreement.

The correlation and agreement between A-LAC and strip A-LAC were assessed by the same methods.

RESULTS

Forty-eight patients were included in the study. As shown in Table 1, 21 patients (44%) were men and 27 (56%) were women. The average age was 53.2 ± 20 years (mean±SD). All of the patients had multiorgan failure and almost half of them had sepsis. Multiorgan failure or multiorgan dysfunction syndrome (MODS) was charac-

terized by the presence of multiple and progressive organ dysfunction severe enough to require intervention for homeostasis in an acutely ill patient. The average values for A LAC, C LAC and strip A LAC were 4.89 ± 4.75 , 4.51 ± 3.75 and 4.73 ± 4.51 mmol/L respectively (mean ± SD.). Although standard arterial lactate values ranged from 1 to 22.5 mmol/L, all but 5 of them were below 10 mmol/L. Details of patients characteristics are listed in Table 1.

Table. 1 Demographic Data (n=48).

Male : female	21:27
Age (year)	53.2 ± 20
Arterial lactate level (mmol/L)	
mean±SD	4.89 ± 4.75
range	1 - 22.5
Underlying diseases/ conditions	
Sepsis/ septic shock (%)	31 (64%)
Hypovolemic shock	4 (8.3%)
Multiorgan failure (%)	48 (100%)

All 48 patients completed the study. Two of the strip capillary lactate values displayed "High" which indicated that the lactate level was too high for the device to determine. The A LA C values for these displays 19.9 and 18.05 mmol/L respectively. One of strip A LAC value displayed "Low" while the A LAC value was 0.6 mmol/L. These values were excluded from correlation and agreement analysis.

Fig. 1 A demonstrates the correlation(r) between A LAC and C LAC, which is 0.89, $p < 0.05$; and Fig. 1 B, the correlation(r) between A LAC and strip A LAC is 0.98, $p < 0.05$. Fig. 2A shows the extent of agreement between A LAC and C LAC measurements. Although the mean of A-C differences was only 0.23 mmol/L, disagreement between A LAC and C LAC was observed in two patients. One of them was an SLE patient with severe vasculitis of the fingers. Her capillary and standard arterial lactate values were 12.2 and 1.72 mmol/L respectively. The other patient had C LAC and A LAC values of 18.7 and 22.5 mmol/L. Disagreement between strip A LAC and A LAC was also noted in 2 patients. Standard and strip lactate levels were 22.5 and 16.8 mmol/L in one and 18.05 and 20.4 mmol/L in the other.

DISCUSSION

The data reported here indicated that, in suspected hyperlactacidemic state, capillary lactate and arterial lactate levels determined by a portable lactate analyzer (Accusport ^{R}) correlated well with arterial lactate levels determined by the standard method. In addition, agreement between the two methods was almost perfect. The tested method, therefore, may have therapeutic roles in patients with hyperlactacidemia.

Disagreement between A LAC and C LAC in two patients can be explained by the patient's underlying conditions. One of them had SLE with severe vasculitis of the fingers which might have interfered with local tissue perfusion. The other had a very high lactate level (A LAC = 22.5 mmol/L and C LAC = 18.7 mmol/L) which exceeded the device's capability. This seldom occurs since most of our patients had their lactate level between 1 and 10 mmol/L. This explanation may be applied to the disagreement found in strip A LAC and A LAC which was found in 2 patients. Thus, when excluding patients with local ischemia and patients with very high lactate level, capillary and arterial lactate level obtained by the strip method would have a good agreement with the results obtained by the standard method.

Hence, we can conclude that; capillary lactate and arterial lactate determined by the tested method, when used and interpreted cautiously, may be an alternative method for the diagnosis of hyperlactacidemia in critically ill patients. The clinical implication of these results is that determination of lactate level in the critical care unit may be performed at the bedside by using this tested method which saves time and reduces the work load. The promptness of the lactate values will enable clinicians to diagnose the perfusion deficit state which will lead to early treatment. Moreover, therapy can be monitored or adjusted correctly, and as a result, the patients' outcome will be improved.

When comparing our findings with other studies to simplify lactate analysis, Gallagher et al reported significant correlation between peripheral venous and arterial lactate in 74 emergency department patients(11). Disagreement was also observed

Figure 1A

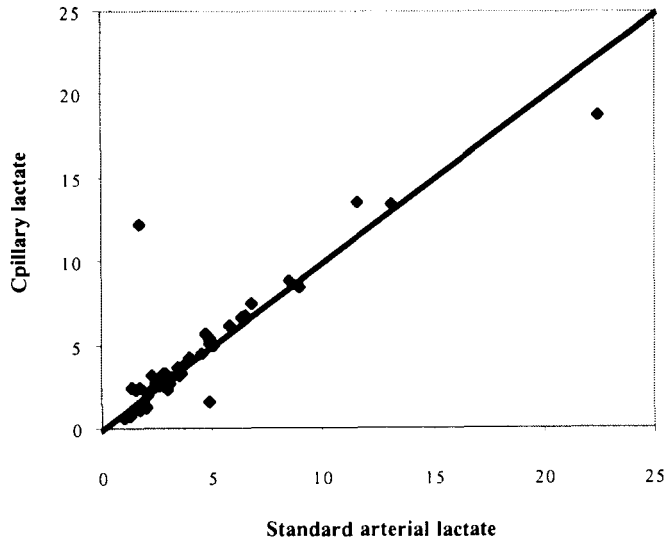

Figure 1B

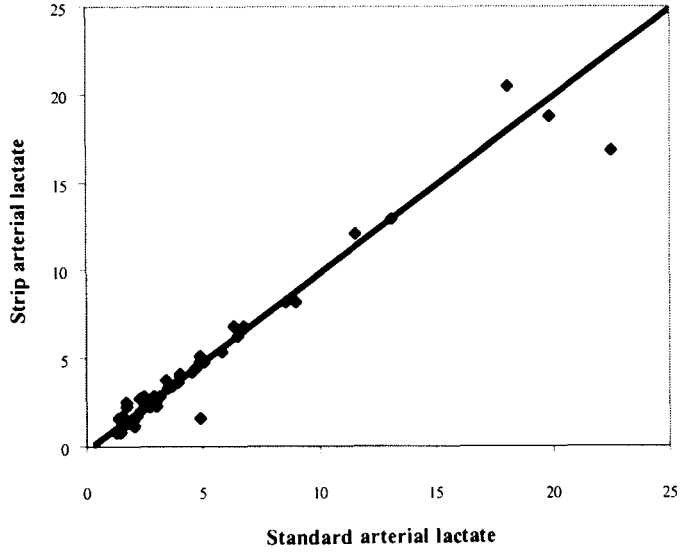

Fig. 1A, B **Correlation between capillary lactate and standard arterial lactate (A), r = 0.89 ($p < 0.05$) and correlation between strip arterial lactate and standard arterial lactate (B), r = 0.98 ($p < 0.05$)**

but the characteristics of these patients were not pointed out. Moreover, the tested system in the study was the standard one. Therefore, the problems of specimen handling and long laboratory process were not solved.

Limitation of capillary lactate determination, as observed from our study, consists of interference of local factors and high lactate level. Patients with vascular deficiency such as vasculitis or vascular occlusive diseases may have

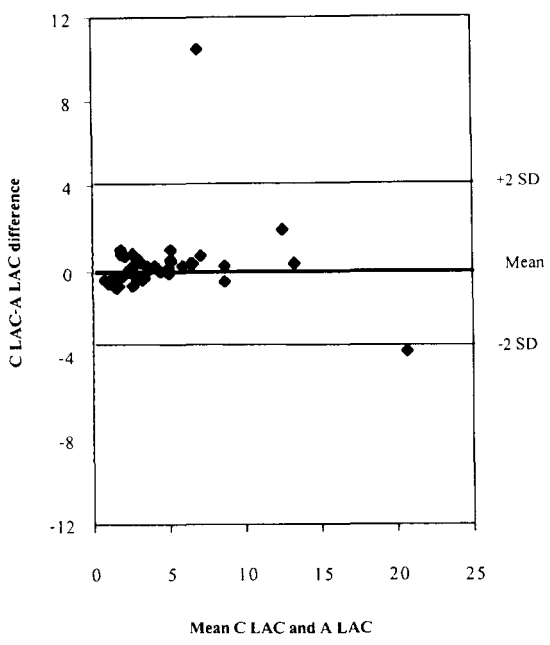

Fig. 2 A

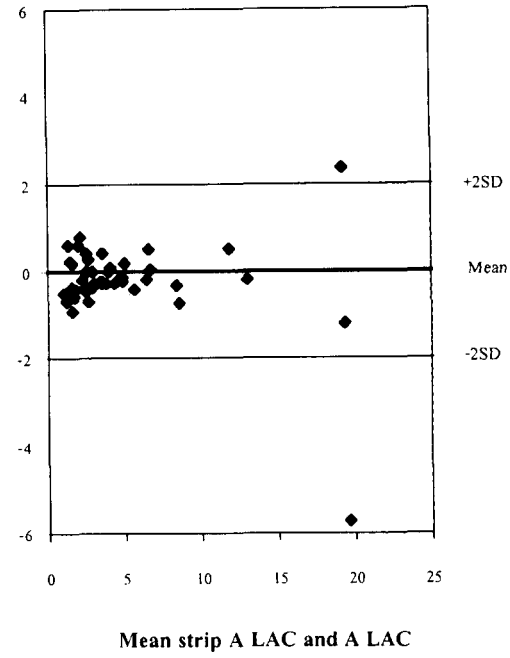

Fig. 2 B

Fig. 2A, B **Plots of the absolute differences between strip capillary lactate and standard arterial lactate against their means(A) and plots of absolute differences between strip arterial lactate and standard arterial lactate against their means (B) according to Bland and Altman[9]. Note that the agreement between the two pairs are almost perfect (see text).**

a falsely high lactate level. Also, caution must be taken when the "High" value is displayed because the actual value is too high for the device to read. Finally, physicians need to know how to interpret a high lactate level, whether it is from perfusion deficit or other abmormalities.

In conclusion, capillary lactate obtained by strip when interpreted cautiously may play a role in the diagnosis of hyperlactacidemia and monitoring the effectiveness of its treatment.

(Received for publication on April 7, 2000)

REFERENCES

1. Cryer HG, Richardson JD, Longmire-Cook S, Brown CM. Oxygen delivery in patients with adult respiratory distress syndrome who undergo surgery. Arch Surg 1989; 124: 1378-85.
2. Tuchschmidt J, Oblitas D, Fried JC. Oxygen consumption in sepsis and septic shock. Crit Care Med 1991 ; 19 : 664-71.
3. Bland RD, Shoemaker WC, Abraham E, Cobo JC. Hemodynamic and oxygen transport patterns in surviving and non surviving postoperative patients. Crit Care Med 1985 ; 13 : 85-90.
4. Bakker J, Coffernils M, Leon M, Gris P, Vincent J-L. Blood lactate levels are superior to oxygen-derived variables in predicting outcome in human septic shock. Chest 1991; 99: 956-62.
5. Abramson D, Scalea TM, Hitchcock R, Trooskin SZ, Henry SM, Greenspan J. Lactate clearance and survival following injury. J Trauma 1993 ; 35 : 584-9.

6. Boehringer Mannheim Corporation: Lactate test strips product information, 1995.
7. Boehringer Mannheim Corporation: Accusport Product Information 1995.
8. Marbach EP, MH Weil. Rapid enzymatic measurement of blood lactate and pyruvate. Clin Chem 1967; 13 : 314.
9. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986 ; 1 : 307-10.
10. Gallagler EJ. Correlation versus agreement : Methods of measurement in medicine. Ann Emerg Med 1996 ; 27 : 236-8.
11. Gallagher EJ, Rodriguez K, Touger M. Agreement between peripheral venous and arterial lactate levels. Ann Emerg Med 1997 ; 29 : 479-83.

การตรวจระดับแลคเตทในเลือดด้วยเครื่องตรวจขนาดเล็ก (Accusport ®) ในผู้ป่วยวิกฤตอายุรศาสตร์

ไชยรัตน์ เพิ่มพิกุล, พ.บ.,*
รณิษฐา รัตนะรัต, พ.บ., นีโลบล เนื่องตัน, พ.บ.***

ผู้รายงานได้ทำการศึกษาความแม่นยำของการตรวจระดับสารแลคเตทในเลือด ด้วยใช้เครื่องมือตรวจชนิดใช้แถบตรวจแบบพกพาโดยอาศัยหยดเลือดจากหลอดเลือดฝอย (C LAC) และหยดเลือดจากหลอดเลือดแดง (strip A LAC) เทียบกับการตรวจมาตรฐานโดยใช้เลือดแดง (A LAC) ในผู้ป่วยที่สงสัยว่าจะมีระดับแลคเตทในเลือดสูง พบว่าในผู้ป่วย 48 ราย ที่มีระดับแลคเตทในเลือดแดงระหว่าง 1–22.5 mmol/L (4.89 ± 4.75, mean ± SD.) วิธีที่ทดสอบไม่สามารถอ่านค่า C LAC ที่สูงได้ในผู้ป่วย 2 ราย (ค่า A LAC เท่ากับ 19.9 และ 18.05 mmol/L) และไม่สามารถอ่านค่า strip A LAC ที่ต่ำได้ในผู้ป่วย 1 ราย (ค่า A LAC เท่ากับ 0.6 mmol/L) สหสัมพันธ์ (correlation, r) ระหว่าง A LAC กับ C LAC, และ A LAC กับ strip A LAC ในผู้ป่วยที่เหลือมีค่าเท่ากับ 0.89 และ 0.98 ตามลำดับ ($p < 0.05$) ส่วนการศึกษาความสอดคล้องพบว่าค่าความแตกต่างระหว่าง C LAC กับ A LAC, และ strip A LAC กับ A LAC ในผู้ป่วยเกือบทุกคนอยู่ในเกณฑ์ความสอดคล้อง สรุปได้ว่าการตรวจระดับแลคเตทในเลือดฝอยและหยดเลือดแดงโดยเครื่องมือดังกล่าวสามารถใช้ในการวินิจฉัยและติดตามผลการรักษาผู้ป่วยที่มีระดับแลคเตทในเลือดสูงได้ ถ้าผู้ใช้มีความระมัดระวังและทราบถึงข้อจำกัด

คำสำคัญ : ระดับแลคเตท, การตรวจวัดระดับแลคเตทในเลือด, ผู้ป่วยวิกฤต

ไชยรัตน์ เพิ่มพิกุล, รณิษฐา รัตนะรัต, นีโลบล เนื่องตัน
จดหมายเหตุทางแพทย์ ฯ 2543; 83: 1348–1353

* ภาควิชาอายุรศาสตร์,
** ภาควิชาชีวเคมี, คณะแพทยศาสตร์ศิริราชพยาบาล, มหาวิทยาลัยมหิดล, กรุงเทพฯ 10700