Comparison of lactate concentration in arterial and venous blood gas analysis

Comparação da concentração de lactato em gasometria arterial e venosa

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Abstract

Lactate is a less complex and low-cost suggestive biomarker of sepsis, which allows the assessment of mortality risk in patients admitted to the intensive care unit (ICU). In this context, the present study aims to compare the concentration of lactate in arterial and venous whole blood gas analysis. This is a case-control study, carried out with database research based on patients treated in the emergency room of a hospital in the city of Joinville (Santa Catarina), between January 1st, 2020 and April 13, 2020. Patients of both genders, aged 18 years or over and with a request for arterial and venous blood gases in the same request were selected. All patients were identified by age, sex and lactate concentration value. Values of $p<0.05$ were considered statistically significant. A total of 101 patients were evaluated during the study period, without significant differences in lactate concentrations between arterial and venous whole blood samples ($p=0.375$). Spearman's correlation analysis showed an association between arterial and venous lactate ($r=0.939$; $p<0.01$) and, in the Bland-Altman verification, the results showed a bias of -0.02 ± 0.24 (CI95 % from -0.67 to 0.52). Arterial and venous whole blood samples did not show significant differences in lactate concentrations in the studied population.

Keywords: Lactic Acid; Blood Gas Analysis, Sepsis.

Resumo

O lactato é um biomarcador sugestivo de sepse de menor complexidade e baixo custo, o qual permite a avaliação do risco de mortalidade em pacientes admitidos em uma unidade de tratamento intensivo (UTI). Nesse contexto, o presente estudo tem como objetivo a comparação entre a concentração de lactato em sangue total arterial e venoso utilizando a análise de gasometria. Esse é um estudo de caso-controle, utilizando dados de pacientes tratados em sala de emergência de um hospital da cidade de Joinville (Santa Catarina), entre 1º de Janeiro de 2020 e 13 de Abril de 2020. Pacientes masculinos e femininos, que possuíssem 18 anos ou mais e tivessem requisição médica para gasometria arterial e venosa foram selecionados. Todos os pacientes foram identificados por idade, gênero e valores de concentração de lactato. Valores de $p<0,05$ foram considerados estatisticamente significativos. Um total de 101 pacientes foram analisados durante o período do estudo, sem diferenças significativas entre as concentrações de lactato em sangue arterial e venoso ($p=0,375$). A análise de correlação de Spearman mostrou uma associação entre lactato venoso e arterial ($r=0,939$; $p<0,01$) e, na verificação de Bland-Altman, os resultados demonstraram um viés de -0,02±0,24 (IC95% de -0,67 a 0,52). As amostras de sangue total arterial e venoso não apresentaram diferenças significativas com relação à concentração de lactato na população estudada.

Palavras-chave: Ácido Láctico; Gasometria; Sepse.

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INTRODUCTION

Gasometry is a test performed to assess the acid-base balance of the blood through the direct assessment of the potential of hydrogen (pH), the partial pressure of carbon dioxide (pCO2) and the partial pressure of oxygen (pO2). There are other possibilities for indirect calculations and analysis, such as bicarbonate (HCO3), base excess (EB), total carbon dioxide (TCO2) and oxygen saturation (sO2), which in turn represents the degree of saturation of hemoglobin by oxygen.[1]

The analysis of these parameters is important to clinically assess acid-base balance deviations, which provides information about the patient's respiratory function and also regarding tissue perfusion conditions.[2] Thus, lactate is cited as a suggestive biomarker for sepsis, with lower cost and which allows the assessment of mortality risk in patients hospitalized in an intensive care unit (ICU). Its concentration corresponds to the patient's mortality, that is, a relationship that presents a direct proportionality between high lactate concentration in the blood and the greater possibility of death prognosis.[3,4]

However, the assessment of lactate in venous blood is not commonly used in clinical practice, as there is no confirming data in the literature that levels of this parameter, when compared between arterial and venous blood, remain stable in acid-base disorders.[5,6]

Therefore, it is understood that the dynamic analysis of the lactate concentration and its duration makes it possible to elucidate diagnoses and suggests that it is directly related to patient mortality.[7,8] Therefore, this study aims to compare the lactate concentration in arterial and venous whole blood samples.

MATERIAL AND METHODS

A case-control study was carried out with research in a database of a Laboratory and developed at the Hans Dieter Schmidt Regional Hospital in Joinville – SC, from January 1st, 2020 to April 13, 2020, after approval by the Committee of Ethics in Research of the hospital itself under the number 4.049.307.

The sample size was defined by convenience, including all patients who met inclusion criteria during the study period. Only patients treated at the Hospital emergency, of both genders, aged equal to or older than 18 years old and with a request for arterial and venous blood gases in the same request. All patients were identified with age, gender and lactate values obtained.

Arterial and venous whole blood samples were collected sequentially, not exceeding a period of 2 minutes, at the time of patient admission, in *a-line luer lock* syringes for blood gases, 3 mL, brand BD, containing lithium heparin with calcium balanced in a proportion of 50 IU of heparin per mL of blood, according to the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC), applied by spraying on the syringe wall, with an aspiration volume of 1.6 mL. Blood samples were analyzed at room temperature (25°C) immediately after collection, not exceeding 15 minutes. To maintain the sample stable, an adaptable BD Hemogard cap was used. Samples were not refrigerated.

For sample analysis, the GEM Premier 3500 gasometer was used, which provides measured and calculated results for blood gases, hematocrit, electrolytes, glucose and lactate. To measure lactate concentrations, an amperometric electrode was used.

For statistical analysis, the Statistical Package for Social Sciences software (SPSS, IBM Corp. Armonk, NY, US), version 26, was used. Initially, a descriptive analysis of the data was performed: for the quantitative variables, the means and the standard deviations and, for qualitative, absolute and relative frequencies. Association measures were subsequently evaluated using specific tests for independent samples (Mann-Whitney U test), after verifying the distribution pattern by preliminary Kolmogorov-Smirnov test. P values below 0.05 were considered statistically significant. Paired samples were analyzed using Spearman's correlation coefficient (r). The Bland-Altman test was performed to describe the agreement between quantitative measurements through the construction of agreement limits.

RESULTS

A total of 101 patients were evaluated during the study period. All underwent arterial and venous whole blood gas tests. In analyzing the data and general characteristics of the patients, the mean age of the population studied was 61 years. There was a predominance of male individuals (Table 1).

As for the results obtained from the analysis of arterial and venous whole blood gases, no significant differences were observed between the lactate concentrations (Table 2). Spearman's correlation analysis (Table 3) resulted in a strong correlation between the variables ($r=0.939$; $p<0.01$) and, in the Bland-Altman analysis, the results showed a bias of -0.02±0.24 (95% CI -0.67 to 0.52).

Table 1

Population characteristics (N = 101).

Variable	Mean / Absolute number	Standard Deviation / Percentages
Age	61,27	1,469
Male	68	67,3%
Female	33	32,7%

Notes: Quantitative variables presented as mean and standard deviation (SD). Qualitative variables presented as absolute numbers and percentages (%).

Table 2

Blood gas characteristics (N = 101).

Variable	Arterial Mean (SD)	Venous Mean (SD)	p values
Lactate	2,208 (0,129)	2,286 (0,127)	0,375**

Abbreviations: Quantitative variables presented as mean and standard deviation (SD). Notes: ***Mann-Whitney* test.

Table 3

Correlation coefficient and agreement for arterial and venous blood samples – subgroup analysis (N = 101).

Variable	Correlation	Bias	IC 95%	p values
LacV e LacA	0,939*	0,02 ± 0,24	-0,67 a 0,52	0,375**

Abbreviations: LacV – venous lactate; LacA – arterial lactate. Notes: *Spearman's correlation. ***Mann-Whitney* test.

DISCUSSION

The evaluation of venous blood lactate is extremely important, as it can prevent hospital mortality and provide important prognostic information. In addition, it is a simple method to be performed, since the puncture is less invasive and painful when compared to arterial puncture. It is known that the assessment of lactate concentration has a better clinical correlation when evaluated serially, as the increase in lactate in patients with sepsis may be secondary to a pyruvate dehydrogenase dysfunction or to an increase in aerobic glycolysis.[9]

Different studies suggest that the plasma lactate concentration value should be obtained through arterial puncture, as venous blood only assesses the corresponding region, that is, it does not provide monitoring of global perfusion.[8,10] However, the present study demonstrates that the concentration of lactate in the whole venous blood does not present a statistically significant difference compared to the concentration of lactate in the whole arterial blood, in addition to showing a strong correlation and an adequate agreement.

The study by Howell et al.[10] showed that, in patients admitted with clinical suspicion of infection, the level of venous lactate predicts hospital mortality within 28 days, regardless of blood pressure, thus adding significant prognostic information to that provided by other predictors clinical trials.

The study by Cicarelli et al.[11] concluded that patients with high lactate, in the first 24 hours after the diagnosis of systemic inflammatory response syndrome (SIRS), did not have more organic dysfunction than patients with normal lactate, however, they had an increased risk of death within seven days. Likewise, researchers have shown that postoperative patients who presented lactate levels above 2 mmol/L at the time of SIRS diagnosis were four times more likely to die in seven days. Therefore, aggressive and effective treatment, with the intention of avoiding septic shock, seems to enable prevention of progression to a refractory state of shock and consequent multiple organ failure. A consistent statement, since a delay in volume resuscitation in these patients and in the institution of inotropic support for myocardial dysfunction increases the risk of death.[11]

An analytical cross-sectional study, with the collection of 32 patients, found that central and not peripheral venous blood can replace arterial blood with good clinical correlation. The authors identified a good correlation and reasonable agreement between lactate levels collected from central and arterial venous blood (r=0.84, p<0.0001). However, when comparing peripheral and arterial venous blood, the correlation was moderate and the clinical agreement relatively low.[9]

Other research has demonstrated the effectiveness of venous lactate as a screening for patients who have suffered some trauma. Elevated venous lactate made it possible to identify a significant association between an increase in lactate and an abbreviated maximum lesion score of 4 and 5 (ANOVA, F=8.26, p<0.001). Similarly, patients with venous lactate ≥ 2 mmol/L had significantly increased relative risks of injury severity score ≥ 13, death, admission to the Intensive Care Unit (ICU) and length of stay > 2 days. In the comparison between venous lactate and arterial lactate: in this case, for screening trauma patients, venous lactate levels were equally effective.[12] Similarly, the results of a research with 64 paired samples from 48 patients indicated strong correlations between central venous and arterial lactate concentrations in the overall correlation (r=0.962, p<0.0001, r2=0.965). For the results of the regression equation, arterial lactate, (0.978 × central venous lactate) -0.137; during the state of shock, (r=0.970, p<0.0001, r2=0.966) and for stable hemodynamics, (r=0.935, p<0.0001, r2=0.962).[13]

However, it is noteworthy that the analysis developed was using plasma lactate instead of whole blood, which may have interfered with the results. In the cohort study by Martin & Priestap,[14] there was a strong correlation (r=0.99) between venous and arterial lactate. Even so, as they did not observe good agreement between the variables, the author's suggestion was to collect as a means of screening venous blood gases to assess the acid-base balance of critically ill patients. Subsequently, also according to the authors, arterial blood gases should be collected to confirm the diagnosis.

The study of Marti et al.[15] with 107 paired samples from 26 patients aimed to test whether venous blood samples collected from the femoral access could be used to estimate arterial lactate levels and central venous oxygen saturation in critically ill patients. Outcomes showed a moderate correlation between central venous oxygen saturation and femoral venous oxygen saturation (r=0.686; p<0.0001), with a bias of 8.24±10.44 (95% limits of agreement: -12.23 to 28.70). There was a strong correlation between femoral and arterial lactate levels (r=0.72, p<0.001) with a bias of -2.71±9.86 (95% limits of agreement: -22.3 to 16.61). The presence of hypoperfusion did not significantly change the results. Another relevant factor during this study was the way in which the levels of venous and arterial lactate led to similar therapeutic approaches, which does not represent harm to the treatment and prognosis of the patients evaluated.[15]

Clinical agreement for venous saturation was inadequate, with different therapeutic decisions in 22.4% of situations; for lactate, it occurred in only 5.2% of situations. As limitations of this study, we can mention the failure to perform a serial assessment of the lactate concentration, as well as an assessment of the serum lactate concentration.

CONCLUSION

Lactate concentrations in whole blood did not show statistically significant differences between arterial and venous blood. In addition, venous and arterial blood gases showed a strong statistical correlation.

It is known that arterial blood samples for lactate measurement can be easily obtained in operating rooms, ICU and/or emergency rooms. However, when there is no clinical justification for arterial blood collection, for example, the need to assess the adequacy of O_2 exchange, the assessment of lactate concentration can be performed by venipuncture, since the arterial puncture is an invasive and painful procedure that requires experience from the phlebotomist. However, more studies must be carried out in order to obtain standardization amongst clinical analysis laboratories, with the proposal of correct and accurate medical conduct, in addition to providing a better possible prognosis for the patient.

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