

Blood Lactate Measurement and Interpretation in Critically Ill Equine Adults and Neonates

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KEYWORDS

• Equine • Lactate • Serial measurement • Lactate clearance

KEY POINTS

- Increases in blood lactate concentration in horses are usually the result of decreased tissue perfusion and oxygen delivery. However, other mechanisms for hyperlactatemia exist and might be important in some critically ill horses.
- Lactate concentrations measured at hospital admission are a useful prognostic guide but there are limitations to its interpretation. Serial lactate measurement or measurement of lactate clearance might improve prognostic usefulness.
- Serial lactate measurement might be a useful guide for therapeutic interventions, particularly early (resuscitative) fluid therapy.

INTRODUCTION

Lactate exists as L-isomers and D-isomers; L-lactate is the stereoisomer produced by mammalian cells and the focus of this review. D-Lactate is primarily a product of bacterial carbohydrate metabolism and is not discussed further, although it is important in some disease conditions, especially in ruminants.¹ L-Lactate has historically been considered a marker of tissue hypoxia and a dead-end product of carbohydrate metabolism. These concepts have required extensive reevaluation over the past 25 years. Hyperlactatemia can occur in the presence of apparently adequate tissue perfusion and oxygen delivery.^{2,3} Lactate can act as an alternative energy source for the brain during cerebral ischemia and the heart during hemorrhagic shock.^{4,5} Rather than a dead-end product, lactate is an important carbohydrate intermediate, which is

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shuttled between tissues.⁶ Lactate might even have a role in cell signaling!⁷ Blood (or plasma) lactate concentration at hospital admission has proved to be a useful indicator of disease severity, but measurements taken at a single time point typically fail to completely discriminate survivors from nonsurvivors. Measures that reflect both the severity and duration of hyperlactatemia in critically ill patients might provide better prognostic information. However, the true value of serial blood lactate measurements may lie in its role as a therapeutic target.

MEASURING LACTATE CONCENTRATIONS

In the blood, lactate is present both in plasma and within erythrocytes^{8,9}; plasma lactate concentrations are most commonly measured, but whole blood lactate concentrations might be more appropriate in some situations. Measurement of whole blood lactate concentration requires erythrolysis and is a weighted average of plasma and intraerythrocyte lactate concentrations. Most clinical lactate measuring devices report plasma concentrations, although whole blood samples are used in some, making them, at least theoretically, more convenient. The methodologies routinely used to measure lactate are isomer specific and detect only L-lactate. In most healthy mammals, the D-isomer exists only in nanomolar concentrations, and special assays are required to determine D-lactate concentrations.¹⁰

Inexpensive, handheld point of care (POC) meters have become popular in human critical care medicine, because they can decrease analytical time and cost. Many of these meters are also widely used in equine medicine, although only a few have been validated for use in the horse.^{11–16} The fact that whole blood rather than plasma samples are used in many of these devices has implications for both the accuracy and interpretation of lactate measurements. One POC meter designed to measure plasma lactate concentrations in humans using whole blood samples was assessed in adult horses admitted for emergency assessment and treatment.¹¹ When using plasma samples, lactate concentrations reported by the POC meter correlated well with values obtained using a standard laboratory-based method. However, the meter could be relatively inaccurate when whole blood samples were used; at lower lactate concentrations (<5 mmol/L), the meter commonly overestimates lactate concentrations by 1 or 2 mmol/L.¹¹ Although this discrepancy might seem inconsequential, it can become clinically relevant when assessing animals with near normal lactate concentrations.

The causes of this inaccuracy are unknown, but similar issues have been reported for handheld glucometers evaluated in horses¹⁷ and other species.¹⁸ Packed cell volume seems to be a factor in some studies, and the algorithms used to calculate plasma lactate concentration in human whole blood samples might not be appropriate for equine samples.¹¹ Equine erythrocytes might also physically interfere with meter function, perhaps because of their rapid sedimentation.

Patient and sample handling can also have clinically important effects on the measurement of blood lactate concentrations. Arterial versus venous sampling has some effect on the measured lactate concentration, but the differences are typically clinically irrelevant¹⁹; venous samples are obviously more convenient to collect and give a better overview of the metabolic status of a patient. Blood lactate concentrations can be increased in struggling animals (or animals that are difficult to capture), and prolonged occlusion of the vessel might cause a slight increase in the lactate concentration.²⁰ Inadequate clearance of lactate-containing fluids (eg, lactated Ringer's solution) from intravenous catheters may falsely increase the measured lactate concentration.²⁰ Conversely, fluids that do not contain lactate might falsely decrease

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