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Correlation between some arterial and venous blood gas parameters in healthy newborn Martina Franca donkey foals from birth to 96 hours of age

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ABSTRACT

In neonatology, blood gas analysis is a useful tool in the evaluation of the health of newborns and plays a key role in early detection of critically ill subjects. Because blood gas analysis parameters have not previously been studied in any depth in donkey foals, this study was performed on 16 healthy Martina Franca donkey foals born after an uncomplicated delivery. Arterial and venous blood samples were collected at 5 minutes and at 12, 24, 72, and 96 hours of age. Blood gas analysis was performed by a portable analyzer, measuring arterial and venous total carbon dioxide, carbon dioxide partial pressure (pCO_2), oxygen partial pressure (pO_2), oxygen saturation (sO_2), bicarbonate, base excess (BE), pH, and lactate (LT). Lower blood pH values, pO_2 and sO_2, and a higher level of lactate were found at birth in comparison with subsequent sampling times. This moderate acidotic profile disappeared at 12 hours, when all the parameters became constant until the end of the study period. As expected, significant differences between arterial and venous blood gas parameters related to the oxygenation, such as pO_2 and sO_2, and partially carbon dioxide partial pressure were found, whereas total carbon dioxide, pH, BE, and LT were comparable in arterial and venous blood samples. For these latter parameters, the highly significant correlation between arterial and venous findings suggests that venous samples could be an acceptable alternative to the arterial sample for blood gas analysis in newborn donkey foals, when the oxygenation status of the patient is not the first goal of patient analysis.

1. Introduction

In mammals, during the perinatal period, the cardiorespiratory system undergoes the most dramatic changes, which affect the ability of the newborn to survive [1]. A short perinatal asphyxia is known to occur in newborns, even under normal conditions, as the result of myometrial contractions and transient imbalance of gas exchange [2]. However, perinatal asphyxia must be quickly and efficiently counteracted by the progressively efficient respiration [3]. The evaluation of blood gas analysis immediately after birth could therefore be useful in detecting the neonates needing special monitoring in the first weeks of life [4]. As reported for human babies, blood gas analysis is important for early evaluation of the health of a newborn [5], providing valuable diagnostic and prognostic information, essential to patient assessment and management. Blood gas analysis aims primarily to measure blood oxygen and carbon dioxide quantity, and pH. To be specific, the analysis provides data regarding blood pH, oxygen (pO_2) and carbon dioxide

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(pCO_2) partial pressures, total carbon dioxide (tCO_2), oxygen saturation (sO_2) but often also lactate, bicarbonate (HCO_3), and base excess (BE). Blood gas analysis can be performed on arterial (ABG) or venous blood (VBG), the former being considered the elective, traditional method, albeit characterized by some limitations, especially when adapted to animals. Although arterial blood sampling is considered a low-risk procedure, bleeding, arterial injury, and infection are recognized as possible side-effects also in humans. In horse foals, performing blood sampling from the brachial, great metatarsal, or palmar arteries requires lateral recumbence restraint [6], easily performed in sick animals but not in healthy, viable neonates. Alternative to ABG, VBG can be a safer procedure, easier to perform, and very convenient especially during animal hospitalization, when many patients have a central venous catheter from which venous blood samples can be quickly and easily retrieved.

Blood gas analysis can be performed by laboratories or by portable analyzers, the latter being much more useful for use under veterinary practice in the field. As reported by Castagnetti et al. [7], the accuracy of some handheld analyzers has been verified for use in equine medicine. Among them is the i-STAT (Abbott Laboratories, Abbott Park, IL, USA), the accuracy of which has previously been demonstrated [8,9].

A quick assessment of neonatal viability is essential to provide the proper care or intensive resuscitation at birth in newborns of every species, to improve the chance of offspring survival. In donkeys, many breeds are recognized by the Food and Agriculture Organization as endangered populations, meaning that the neonatal survival is even more crucial. The Martina Franca donkey breed has been recognized as endangered because of the small number of approved-for-breeding jackasses (48) and jennies (515) [10]. Although one study provides data about the hematology, biochemistry, and an analysis of VBGs in the first 24 hours of life of donkey foals [11], to the author's knowledge, no data are available about the suitability of using venous blood instead of arterial blood for gas analysis in donkey foals in the first 96 hours of age.

Therefore, the aims of the present study were to define VBG and ABG analysis parameters in healthy newborn donkey foals in the first 96 hours of age and to verify the agreement between arterial and venous values of blood gas and acid-base parameters.

2. Material and methods

2.1. Animals

The study was conducted during the 2015 breeding season on donkeys housed at the Veterinary Teaching Farm of the University of Teramo. The clinical study was approved by the Interuniversity Ethics Committee for Animal Experimentation (CEISA, Protocol number #45/2013/CEISA/COM).

According to the criteria for normal, spontaneous parturition and the requisites for healthy, mature, and viable donkey foals [11], 16 Martina Franca donkey foals were enrolled in the present study. Two weeks before the expected date of delivery, every jenny aged between 4 and 12 years and 310 to 390 kg was moved to box equipped with two closed-circuit television cameras for video surveillance of birth.

Within 5 minutes after birth, foals were clinically evaluated for maturity and congenital defects, weighed, and submitted to APGAR score index measurement [12]. In this study, the APGAR score was calculated on appearance (pink mucous membranes—score 2; pale pink mucous membrane—score 1; and gray/blue—score 0), the pulse (>60 bpm and regular rhythm—score 2; irregular rhythm or <60 bpm—score 1; and absent rhythm—score 0), grimace (avoidance of stimulation—score 2; grimace/weak—score 1; and absent response—score 0), activity (sternal/active—score 2; hypotonic—score 1; and atonic—score 0), and respiration (regular—score 2; irregular—score 1; and absent—score 0).

2.2. Blood sampling and gas analysis

All the 16 donkey foals underwent arterial and venous blood sampling according to the following schedule: 5 minutes (T1), 12 hours (T2), 24 hours (T3), 48 hours (T4), and 96 hours (T5) after birth. The sampling schedule was adjusted to reduce the number of blood collections in the animals. Arterial blood samples were collected from the great metatarsal artery on foals in lateral recumbence by using a 1-mL heparinized syringe. Venous samples were collected soon after the arterial sample from the jugular vein; foals were restrained in sternal recumbence for the first sample and in standing position for the subsequent samplings. All samples were collected by the same vet, in accordance with the good veterinary practice, and did not cause evident pain to the animal.

Immediately after collection, blood samples were loaded on a CG4+ cartridge (Abbott Laboratories, Chicago, USA) and analyzed using a portable blood gas analyzer (i-STAT System, Abbott Laboratories, Abbott Park, IL, USA) as previously reported [13]. The following parameters were analyzed: total CO_2 (tCO_2, mmol/L), partial pressure CO_2 (pCO_2, mm Hg), partial pressure O_2 (pO_2, mm Hg), oxygen saturation (sO_2, %), HCO_3 (mmol/L), base excess (BE, mmol/L), pH, and lactate (LT, mmol/L).

2.3. Statistical analysis

Data are presented as mean ± standard deviation (SD). Differences for each parameter between different sampling times were tested by univariate ANOVA followed by a Scheffè posthoc test, where appropriate. Correlations between arterial and venous parameters were tested using Pearson's correlation coefficient. Significance was set at $P < 0.05$. The agreement between arterial and venous blood and acid-base parameters was also evaluated using the Bland–Altman plot, as previously described [14,15].

Statistical analyses were performed using SPSS 15.0 (SPSS Inc. Chicago, IL, USA), the Bland–Altman plot was performed using Medcalc 12 (Medcalc software bvba, Ostend, Belgium).