Vital Parameters in Newborn Thoroughbred Foals during the First Week of Life

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Abstract: The neonatal period is a critical stage when the newborn has to adapt almost all the body systems to extra uterine life. Because sedative drugs greatly affect foal's respiratory system, monitoring blood gas values can be critical in order to maintain a normal respiratory function and guarantee the foal's survival. Therefore, the aim of the present study was to monitor daily how vital parameters change in six healthy Thoroughbred foals over the first week of life. Heart rate (HR), respiratory rate (RR), rectal temperature (RT) were daily recorded. Arterial blood samples were also collected to determine carbon dioxide partial pressure (pCO_2), oxygen partial pressure (pO_2), pH, and bicarbonate concentration (HCO^-_3). The statistical analysis showed significant modifications in HR ($P<0.0001$), pO_2 ($P<0.0001$), pCO_2 ($P=0.0492$), pH ($P=0.0007$), and HCO^-_3 ($P=0.0225$) during the study. The present study showed the adjustments occurring in foal's respiratory function and acid-base balance, day by day, over the first week of life. This information on foal's vital parameters might help equine clinicians when considering using whatever therapeutic or sedative/anaesthetic drugs, as the delicacy of both the circulatory and pulmonary systems of a very young foal needs to be taken into account.

Keywords: Physiological parameters, foals, blood gas, acid-base balance.

1. INTRODUCTION

The transition from a foetus, protected and nourished within the uterus, to a free-living neonate is probably the most profound change the newborn have to face. Therefore, the neonatal period is a critical stage when the newborn has to adapt its body systems to extra uterine life. The time during which these changes take place is known as the adaptive period. At this time, foals are metabolically instable, and susceptible to a number of congenital and acquired diseases that can compromise the health conditions of the newborn and its odd of surviving. Among body functions, the cardio-respiratory system plays a critical role to guarantee foal survival. Studies on acid-base balance and blood gas pressure showed that moderate metabolic and respiratory acidosis is likely to occur at birth and during the first two days of life in piglets [1]. Specific literature has investigated the postnatal development of respiratory function and of acid-base balance in lambs during experimental hypoxia or normoxia and/ or hypoxic hypercapnia [2-6], in calves [7], in premature and normal foals at different periods of neonatal life [8-12]. In particular, young foals are susceptible to a number of neonatal syndromes affecting the cardiovascular and respiratory systems that are mayor causes of death in newborn foals [13]. Therefore, a specific knowledge about cardiac and respiratory functions is essential in order to provide the best therapeutic aid to neonatal foals. To this end, the evaluation of vital parameters such as heart rate, respiratory rate, body temperature, blood gas and acid-base status represent important clinical investigations to promptly diagnose the onset of neonatal diseases that can lead the foal to death. Furthermore, prevalent pathological conditions occurring in young foals, such as hernia or limb deformities, usually requires surgical treatments hence sedation and anaesthesia [13]. Since sedative drugs greatly affect the respiratory system, and young foals tend to lapse into recumbency with sedation, monitoring blood gas values can be critical in order to maintain a normal respiratory function and guarantee the foal's survival. Therefore, the aim of the present study was to monitor daily how vital parameters change in healthy foals over the first week of life.

2. MATERIALS AND METHOD

Six healthy, full-term, Thoroughbred foals (mean body weight 42 ± 3 kg) were enrolled in the study with the informed owner consent. The foals were monitored from the 1st day to the 6th day of life. All recordings and blood sampling were performed daily in the morning (08.00 AM). Heart rate (HR) was assessed by means of a heart rate monitor (Equine Polar Vet Check), respiratory rate (RR) was assessed by the same clinician over 5-minute period, rectal temperature (RT) was recorded by means of a veterinary digital thermometer (Gima, Milan, Italy). Blood samples were collected from the brachial artery by using pre-heparinized ventilated syringes for hemogas analysis (frozen-dry lithium-heparin) as described by Fisher *et al.* [14].

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Obtained samples were analyzed within 15 minutes from the collection using a selective ions hemogas analyzer (Stat Profile Phox, Nova Biomedical). The following blood parameters were analysed: carbon dioxide partial pressure (pCO_2), oxygen partial pressure (pO_2), pH, and bicarbonate concentration (HCO^-_3). Because of the influence of body temperature on blood gas partial pressure [15], the analyzer reference temperature was individually set the rectal temperature recorded for each animal, prior performing the analysis.

The obtained data were tested for normal distribution using the Kolmogorov-Smirnov normality test. One-way repeated measure ANOVA was applied to assess significant effects of the experimental period on blood parameters. When significant differences were found the Tukey post hoc comparison test was applied. P values <0.05 were considered statistically significant. All data were analyzed using the PRISM 6 package (GraphPad Software Inc., La Jolla, California).

All treatments, housing and animal care were carried out in accordance with the standards recommended by the EU Directive 2010/63/EU for animal experiments.

3. RESULTS

All the foals included in the study were able to stand and nurse within two hours of delivery, and stayed healthy throughout the experimental period. All data recorded during the study passed the Kolmogorov-Smirnov normality test. The statistical analysis showed significant modifications in HR ($P<0.0001$), pO_2 ($P<0.0001$), pCO_2 ($P=0.0492$), pH ($P=0.0007$), and HCO^-_3 ($P=0.0225$). No significant difference was found in RR (26±1 breath/min) and RT (38.6±0.3°C) that stayed constant during the study. Figure **1** shows the mean values ± standard deviations and the related statistical significances of HR, RR, and RT recorded in newborn foals during the study. Blood gas and acid-base mean values (pO_2, pCO_2, pH and HCO^-_3) together with statistical significances are shown in Figure **2**.

4. DISCUSSION

The most significant changes in foal vital parameters occurred in the first three days of life. The highest HR values were recorded in the first day after birth. This finding is probably due to the significant physical effort carried out by the foal attempting to stand and nurse [8]. In the following days a gradual decrease in HR was observed, although mean HR, settled around 80-100 beats/min, was significantly

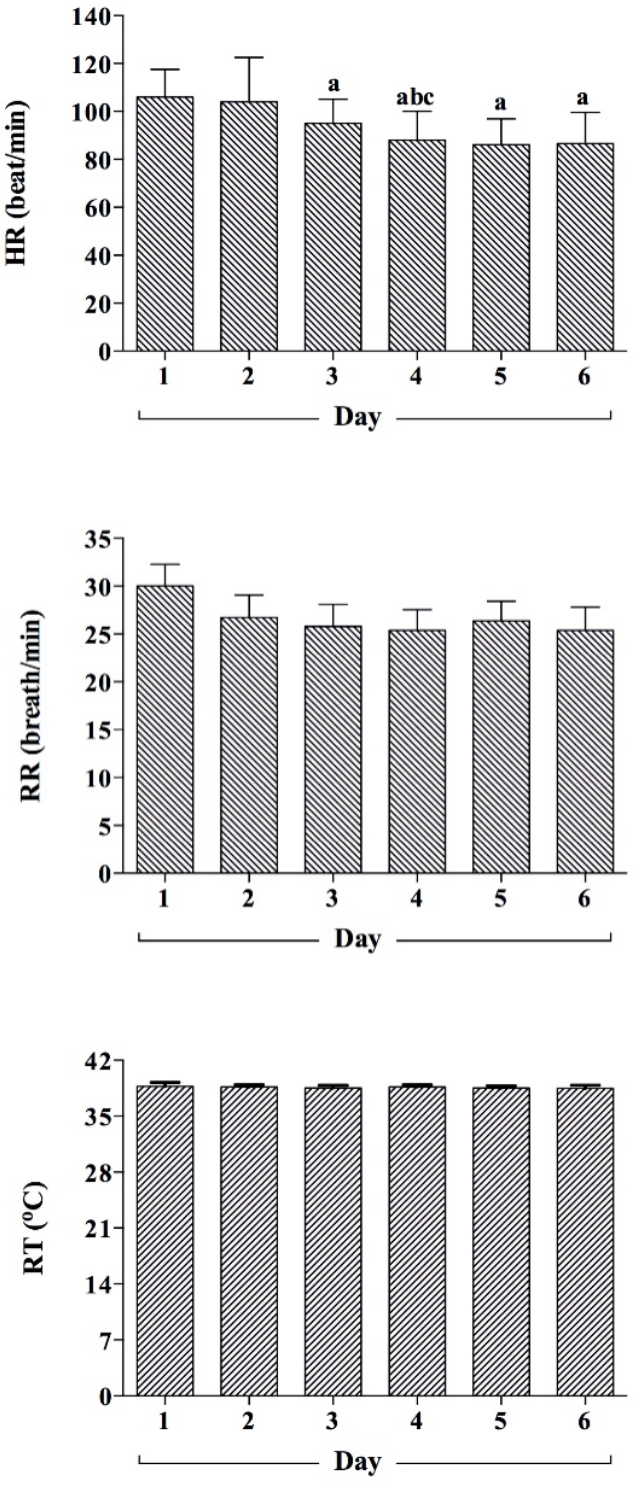

Figure 1: Mean values ± standard deviations of heart rate (HR), respiratory rate (RR), and rectal temperature (RT) recorded in newborn foals during the experimental period (1^{st}-6^{th} day after birth). The following lower cases indicate the statistical significances ($P<0.05$): **a** *vs*. 1; **b** *vs*. 2; **c** *vs*. 3.

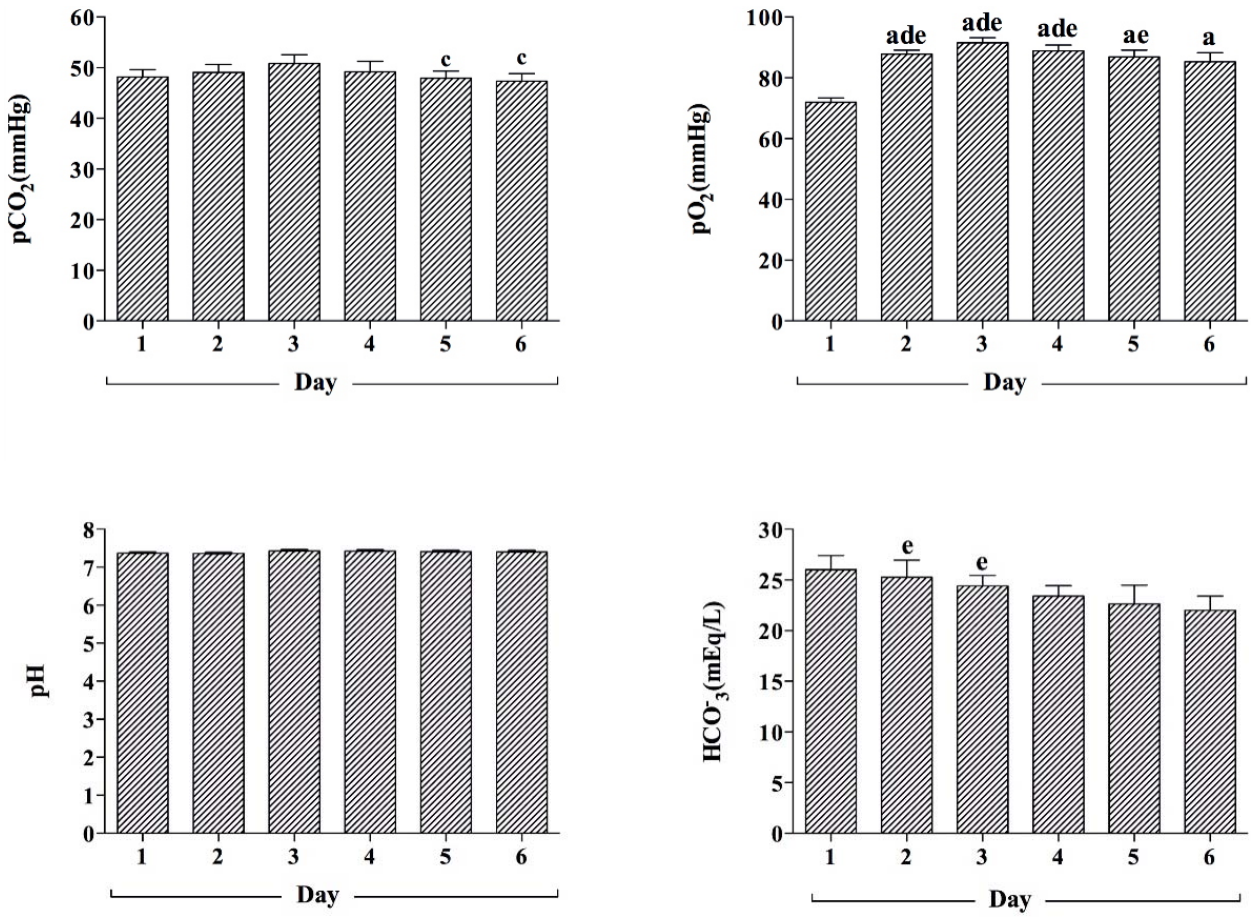

Figure 2: Mean values ± standard deviations of carbon dioxide partial pressure (pCO_2), oxygen partial pressure (pO_2), pH, and bicarbonate concentration (HCO^-_3) recorded in newborn foals during the experimental period (1^{st}-6^{th} day after birth). The following lower cases indicate the statistical significances ($P<0.05$): **a** *vs*. 1; **c** *vs*. 3; **d** *vs*. 5; **e** *vs*. 6.

higher compared to HR range of adult horses (32-44 beats/min) [16]. The HR pattern recorded in the first 6 days of foal's life might depend on the adjustments occurring in the cardio-circulatory system at this stage. Conditions as the foramen ovale and the arterial duct close, or the right-left cardiac shunt that usually resolves over few weeks after birth [17], are common examples of such adjustments. In our study foals showed about 1^oC higher body temperature than normal values of adult horses [16]. It is known that thermal homeostasis is subordinated to the complete maturity, as well as glycogen and fat reserves of the newborn body system [17]; however, the lack of significant modifications in foal's RT over the first week of life highlights that thermoregulation mechanisms are promptly effective after birth. Despite this, some body functions are not totally mature in newborns and compensative mechanisms are likely to occur [18]. According to our results this condition of partial immaturity affects foals' respiratory system. The progressive increase in pO_2 concentration that shifted from 71.96 mmHg (1^{st} day of life) to a maximum value of 91.53 mmHg within three days provides evidence of the rapid improvement in pulmonary function. Low pO_2 blood levels recorded at birth were associated with high CO_2 tension in blood. Effectively, the foal is not able to remove CO_2 at the same rate of its production because of the immaturity of the respiratory system. This results in increased carbon dioxide alveolar percentage with increased blood pCO_2 levels in the first three days of the experimental period. CO_2 retention would cause an increase in carbonic acid concentration and a lowering pH, as a consequence [19]. The slight hypoxia and hypercapnia occurring in newborns over the first hours of life determine a difference in blood circulating volume depending on tissues and organs. Thereby, a proper O_2 supply is guaranteed to organs like heart and brain [18] rather than muscles and skin. This condition leads to an essential use of anaerobic glycolysis up to 96% more than adults [20], resulting in accumulation of lactate and the onset of a mixed respiratory-metabolic acidosis. To counterbalance the acidosis status, the

carotid chemoreceptors show an increased O_2 sensitivity [21] determining a consistent rise in tidalic volume [22]. This adjustment might explain the significant increase in pO_2 recorded in our study after the 1st day of life.

In conclusion, the present study analysed the main vital parameters in healthy foals showing the adjustments occurring in respiratory function and acid-base balance, day by day, over the first week of life. Our results provide suitable information on foal's vital parameters to equine clinician, as the delicacy of both the circulatory and pulmonary systems needs to be taken into account when considering using whatever therapeutic or sedative/anaesthetic drugs on a very young foal.

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