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Original article

Changes in acid-base balance in neonatal goats before and two hours after colostrum intake

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Abstract

The purpose of the study was to obtain values of acid-base balance and basic biochemical parameters in neonatal kids of the White Shorthaired goat depending on colostrum intake. The research was focused on changes in acid-base balance parameters and basic biochemical parameters in neonatal kids before and two hours after colostrum intake. Total of 66 blood samples were taken from 33 neonatal kids. Blood pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), bicarbonate concentration ($cHCO_3^-$), base excess (BE), oxygen saturation (cSO_2), total carbon dioxide (TCO_2), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), chloride (Cl^-), glucose (Glu), lactate (Lac), creatinine (Crea), hematocrit (Hct) and haemoglobin (Hgb) were measured. There were no statistically significant differences in acid-base balance parameters such as pO_2, pCO_2, TCO_2, cSO_2 and biochemical parameters such as Na^+, K^+, Ca^{2+}, lactate between the two groups - before colostrum intake (group BF) and after colostrum intake (group AF). There were statistically significant differences in acid-base balance parameters such as pH, BE, $cHCO_3^-$ between these groups. Differences in acid-base values of pH, BE and $cHCO_3^-$ were statistically significant ($p<0.05$). Differences in biochemical values of creatinine and glucose were statistically significant ($p<0.05$). Differences in values of hematocrit and haemoglobin were statistically significant ($p<0.05$). The present results are important for veterinary practice and can improve the neonatal care especially for impaired kids.

Key words: acid-base balance parameters, blood, kids, goats, colostrum

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Introduction

For new-born animals, the first moments of their life out of the intrauterine environment are very demanding and the first hours after birth are the most important for survival. After cutting the umbilical cord, a new-born animal has to adapt to extrauterine life and stabilize its homeostatic environment (Piccione et al. 2006). The period, during which a new-born animal is adapting to life beyond the uterus, is referred to as its adaptation period. Metabolic, thermoregulation, respiratory and cardiovascular mechanisms must become matured (Nowak et al. 2000). If a new-born animal adapts quickly, there is a great chance of its survival and successful development to its maturity. Because of the syndesmochorialis placenta, new-born animals are born agamaglobulinemic and, therefore, colostrum containing immunoglobulins IgG and lactoferrin, which are important to obtain passive immunity, is needed to be administered to them as soon as possible after the birth, (Gokce et al. 2014). The new-born animals are born with limited energy reserves and they need to supply it as quickly as possible to maintain homeothermia and, thus, support the metabolism development. Meanwhile, the energy is gained by the utilization of brown adipose tissue and from muscle tremors. The energy can be provided by receiving the high-quality colostrum as soon as possible (Nowak et al. 2006). Acid-base balance studies and studies on piglet blood gases revealed rapid modification of mild metabolic and respiratory acidosis to normal within 2 days after birth (Andrén et al. 1982). Investigation of the acid-base balance of new-born lambs showed significant metabolic acidosis immediately after birth that remained for 1 hour. The main factor of acidosis is the increase in lactic acid level during muscle glycogenolysis and hypoxia during the birth. In addition, uterus contractions cause a reduction in placental circulation and, thus, a lower oxygen supply to the foetus. Moreover, the amniotic fluid in the lung prevents gas exchange and, thus, maintains hypoxia even after the birth (Vanucchi et al. 2012). Once the new-born animal begins to breathe after the birth, the pulmonary ventilation and perfusion increase, CO_2 excretion also increases, and pCO_2 is decreased and O_2 is increased in blood. Furthermore, the neonatal acidosis increases Ca^{2+} ion content and the Ca^{2+} ion content decreases within 6 hours after the acidosis compensation. This suggests that pH and Ca^{2+} are 2 dependent parameters affecting the neonatal acidosis (Varga et al. 2001). An important parameter in the acid-base balance is the role of lactate, which is a component of respiratory and metabolic acidosis. The lactate content is increased in the case of acidosis and its elimination from a body takes longer time compared to CO_2, which is eliminated quickly from the body by respiration (Bleul et al. 2013, Homerovsky et al. 2017). For ruminant animals, such as goat kids, the reference range of the acid-base balance has not been established yet. However, this is very important for veterinary medicine and science. The reference range was determined for the goat kids during the first week of their life and, then, for the 6-week-old goat kids during their ablactation (Piccione et al. 2006, Redlberger et al. 2017). Because of the increasing interest in rescue of new-born animals' life after their birth, it is good to know physiological values of the acid-base balance. Therefore, this was study is focused on determination of the reference acid-base balance ranges for neonatal goat kids just after the birth. For this purpose the White Shorthaired goat was selected, as the most frequent goat breed in the Czech Republic.

Materials and Methods

Material

The study was approved by the Ministry of Education, Youth and Sports of Czech Republic (No. MSMT – 42306/2018 – 3). All procedures were done with the approval of the Ethics Committee of the University of Veterinary and Pharmaceutical Science in Brno. The White Shorthaired goat breed with good milk yield was selected for this project. The experiment was performed on a commercial dairy farm located in Ratibořice (Czech Republic). Sixteen goats and thirty-three kids were examined. The kids were born between January and February 2018. The animals were housed in a stable with a straw bedding. The indoor temperature was around 10°C. No assistance was necessary during the deliveries. The first round of the sampling was performed within 10 minutes following the birth. The second round was done two hours after the first colostrum feeding. Each kid was fed colostrum from their mothers. Venous blood samples from each animals were collected into 2 ml tube. Venous blood was obtained from jugular vein. Blood was collected by a 20G needle. Blood for acid-base balance parameters examination was collected to the special anaerobic tubes with heparin S-Monovette® (Sarstedt AG and Co. KG). Samples of blood were analyzed immediately after sampling. Only healthy new born kids were included in the study. Basic clinical examination was performed in each kid focusing mainly on the presence of good sucking reflex and absence of asphyxia or aspiration of fetal fluids as part of labour complications. Furthermore, antiseptic treatment of the umbilical cord was made by iodine tincture and the kids were cleaned by does to enhance their successful rearing.

Table 1. Mean levels (±SD) of acid-base balance parameters immediately after birth and two hours after colostrum intake in neonatal goat kids (n=33).

Parameter	Before feeding (BF)	After feeding (AF)	p-value
pH	7.31 ± 0.06	7.40 ± 0.04	p=0.00001*
pCO_2(mmHg)	51.38 ± 7.13	43.95 ± 6.08	p=0.682
pO_2(mmHg)	18.23 ± 4.80	17.10 ± 5.40	p=0.638
$cHCO_3^-$ (mmol/L)	25.67 ± 2.83	27.05 ± 2.89	p=0.012*
$cTCO_2$(mmol/L)	27.25 ± 2.93	28.40 ± 3.01	p=0.072
BE (mmol/L)	-0.62 ± 3.33	2.23 ± 3.07	p=0.002*
cSO_2(%)	23.38 ± 9.29	24.98 ± 12.75	p=0.412
Hct (%)	31.57 ± 5.36	28.85 ± 4.82	p=0.0002*
cHgb (g/L)	107.36 ± 17.97	98.12 ± 16.41	p=0.0002*

SD – standart deviation, * statistically significant
Before feeding (BF) = immediately after birth, after feeding (AF) = two hours after colostrum intake

Table 2. Mean levels (±SD) of electrolytes parameters immediately after birth and two hours after colostrum intake in neonatal goat kids (n=33).

Parameter	Before feeding (BF)	After feeding (AF)	p-value
Na^+ (mmol/L)	141.36 ± 4.8	142.18 ± 3.70	p=0.095
K^+ (mmol/L)	4.56 ± 0.71	4.32 ± 0.53	p=0.603
Ca^{2+} (mmol/L)	1.19 ± 0.27	1.17 ± 0.21	p=0.803
Cl^- (mmol/L)	108.68 ± 4.38	106.64 ± 3.25	p=0.007*

SD – standart deviation, * statistically significant
Before feeding (BF) = immediately after birth, after feeding (AF) = two hours after colostrum intake

Table 3. Mean levels (±SD) of other biochemical parameters immediately after birth and two hours after colostrum intake in neonatal goat kids (n=33).

Parameter	Before feeding (BF)	After feeding (AF)	p-value
Glucose (mmol/L)	3.04 ± 1.67	5.75 ± 2.42	p=0.009*
Lactates (mmol/L)	4.83 ± 2.15	3.57 ± 0.98	p=0.234
Creatinin (μmol/L)	201.50 ± 45.47	179.71 ± 44.18	p=0.002*

SD – standart deviation, * statistically significant
Before feeding (BF) = immediately after birth, after feeding (AF) = two hours after colostrum intake

Methods

The samples, notably complete acid-base balance parameters and electrolytic profile were analyzed immediately after their collection using the automatic acid-base analyzer EpocBlood Analysis Systém (Epocal, CAN). Following parameters were measured: blood pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), bicarbonate concentration ($cHCO_3^-$), base excess (BE), oxygen saturation (cSO_2), total carbon dioxide (TCO_2), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), chloride (Cl^-), glucose (Glu), lactate (Lac), creatinine (Crea), hematocrit (Hct) and haemoglobin (Hgb). Statistical analysis was appied to investigate differences in the above-selected blood parameters before and after the colostrum feeding. The parameter values were tested for the homogenity of variances (Hartley-Cochran-Bartlett test) and the normality of distribution (Shapiro-Wilk test). The Wilcoxon signed rank test was used for statistical analysis. Statistical significance was set at p=0.05. All results were expressed as mean and standart deviation (±SD).

Results

Tables 1, 2 and 3 show the results of all measured parameters expressed as a mean value and a standard deviation (SD). There were statistically significant differences in acid-base balance such as pH, $cHCO_3^-$, BE ($p<0.05$). In Table 1, the AF group (After Feeding) shows clearly increasing pH to the physiological value. The pH values were increased on average by 0.09 ($p=0.00001$). The increase in BE (base excess) for the group AF (After Feeding) from negative values to positive ones is evident; the BE value were increased on average by 2.85 mmol/L ($p=0.002$). For the AF group (After Feeding), the values of the $cHCO_3^-$ parameter increased as well, the $cHCO_3^-$ values were increased on average by 1.38 mmol/L ($p=0.0117$). There were no statistically significant differences in other acid-base balance parameters such as pO_2, pCO_2, $cTCO_2$, cSO_2. The differences in Na^+, K^+, Ca^{2+} electrolytes, shown in Table 2, were statistically insignificant. For the group AF (After Feeding), only Cl^- electrolyte level decreased and this difference was statistically significant ($p<0.05$). The Cl^- values were decreased on average by 2.04 mmol/L ($p=0.007$). The measured differences in Lac, shown in Table 3, were statistically insignificant. For other measured biochemical parameters, such as Crea, there was a decrease in the AF group (After Feeding); Crea ($p<0.05$) was statistically significant. The Crea values were decreased on average by 21.79 µmol/L ($p=0.0024$). On the contrary, Glu increased significantly in the group AF (After feeding) and, again, this increase was statistically significant ($p<0.05$). The Glu values were increased on average by 2.71 mmol/L ($p=0.009$).

Discussion

In this study, we showed significant differences in neonatal kids before and after colostrum intake. It is evident that the colostrum plays an irreplaceable role in the new-born animal development. For its survival, a new-born animal needs to restore its acid-base balance and receive enough energy as soon as possible. The results show that the acid-base balance parameters, content of electrolytes, glucose, lactate, and creatinine change significantly within 2 hours after colostrum intake.

After birth, neonatal animals show hypoxemia which they attempt to cope by tachycardia and tachypnoea. New-born animals are born in acidosis due to metabolic and respiratory causes. Birth acidosis occurs due to reduced BE and increased pCO_2 (Vannucchi et al. 2012). In the present experiment, significant differences in pH and BE were observed within 2 hours after birth. In AF group, pH value from 7.31 to 7.40 was reached. This show how a healthy organism can cope with mild metabolic acidosis very quickly. Piccione et al. (2006) measured the pH value of 7.40 for goat kids only on the fourth day after their birth, and even for lambs, the value was not higher than pH 7.38 only on the seventh day after their birth, otherwise it was kept at a low pH level of 7.35. The BE -0.62mmol/L values in AF group reached 2.23 mmol/L and pCO_2 was changed from 51.38 mmHg to 43.95 mmHg. Therefore, we can confirm that the animal can get from the acidotic state into the acid-base balance within 2 hours after colostrum intake. Even for calves, the acid-base balance is balanced out quickly, where BE changed from -2.3 mmol/L to 1.1 mmol/L and pCO_2 from 59.8 mmHg to 50.4 mmHg within 6 hours (Varga et al. 2001).

In our research, there was a lower lactate concentration in AF group. There was a significant reduction in blood lactate from 4.83 mmol/L to 3.57 mmol/L. In the case of postnatal hypercapnia and hypoxia, cells must be supplied with energy that is derived from anaerobic glycolysis, which leads to lactate production and, consequently, to metabolic acidosis (Bleul et al. 2007). Therefore, new-born animals show high values after their birth. For 20–day-old goat kids, the measured lactate value was 2.65 mmol/L, and for 50-day-old goat kids, the value was 2.81 mmol/L (Antunović et al. 2017).

Furthermore, there was also reduced creatinine concentration in blood, it decreased from 201.50 µmol/L to 179.71 µmol/L. Within several weeks, however, the creatinine decrease to lower levels which for 20-day-old and 50-day-old goat kids represent the range around 51.43 µmol/L and 52.07, respectively (Antunović et al. 2017). Thus, it is evident that the creatinine is reduced significantly during the young animal life, up to one-fourth values. The creatinine concentration is used as an indicator of nitrogen metabolism and for proper renal excretion activity, i.e. glomerular filtration rate (Herosimczyk et al. 2011). The significant decrease in blood plasma creatinine concentration is due to increased glomerular rate (Kurz et al. 1991).

Immediately after the birth, significantly high level of chlorides of 108.68 mmol/L were demonstrated in the young animals, which dropped rapidly to 106.64 mmol/L after colostrum intake. Herosimczyk et al. (2011) also demonstrated the highest levels of chlorides for calves after their birth, which decreased with their age. Hypochloraemia occurs in the case of loss of chloride salts by gastric secretion and, partly, by intestine secretion (Seifter et al. 2016). This significant decrease in chlorides within two hours after the birth is caused likely by the metabolic acidosis compensation, which occurs probably due to hypoxia after the birth. Changes in chloride levels compensate for the acid-base status of an organism. Decreases in chlorides could be caused also by drinking the colostrum after the birth. After feed intake, the need for chlorides in the digestive tract increases, especially in the abomasum to produce the abomasum juice. These necessary chlorides are transferred from blood circulation; therefore, there may be a decrease in chlorides in the blood. Both of these assumptions require further research.

After birth, a new-born animal begins to utilize its brown adipose tissue as a source of energy, so it is important that they should to receive sufficient amount of colostrum as soon as possible after birth in order to get instantaneous energy – glucose. Immediately after birth, the neonate is born with a small reserve of glucose which is consumes quickly. In our study, the postnatal blood concentration of glucose was 3.04 mmol/L, however, it increased significantly in 2 hours after drinking the colostrum, namely to 5.75 mmol/L. Antunović et al. (2017) measured the value of 5.08 mmol/L for 20-day-old and 50-day-old goat kids. The glucose value is stable around 5 mmol/L up to the week 12 of their life during the growth of a young animal. From the week 13, it begins slowly decreasing to a stable value of 3.5 mmol/L between the weeks 49 and 56 (Redlberger et al. 2017). For lambs, the blood glucose level increases during the first month of life; then, the glucose level begins to decrease progressively. The level is stabilized at the week 9 of their life (Elnageebet al. 2013). Vannucchi et al. (2012) proved that lambs can balance hypoglycaemia within 5 to 60 minutes, provided that colostrum is early administered.

Conclusions

Drinking the colostrum as soon as possible after birth is vital for the new-born animals. The results show that the acid-base balance changes from the acidotic state to the normal acid-base balance values within 2 hours after colostrum intake. Biochemical parameters are modified also. This investigation provided us with values of selected parameters we can work in practice with. This is especially important in the case of new-born animal rescue because there have been no values for the ABR parameters or selected biochemical parameters for the new-born animals.

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