

NATRIURETIC AND ANTINATRIURETIC RESPONSE TO LACTOSE LOAD IN ONE-WEEK-OLD CALVES

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Abstract. The current study was performed to determine the effect of short term administration of milk replacer with excessive amount of lactose on changes in the concentration of atrial natriuretic peptide (ANP) and aldosterone (ALDO) in the blood plasma of one-week-old calves. The experiment was carried out on Polish Holstein-Friesian var. Black-and-White male calves. Animals were fed the milk replacer twice a day in amount of 10% of body weight. In the evening (first day of the experiment) and in the morning (second day of the experiment), monohydrate lactose in amount of $1 \text{ g} \cdot \text{kg}^{-1}$ of body weight was added into the milk replacer. The present study shows the opposite trend of changes of ANP (increase) and ALDO (decrease) in response to administration of lactose with milk replacer formulation. Average concentration of ANP before the administration of lactose was $77.46 \text{ pg} \cdot \text{ml}^{-1}$ and ALDO was $86.28 \text{ pg} \cdot \text{ml}^{-1}$. After the application of lactose, increased concentration of ANP was observed ($83.91 \text{ pg} \cdot \text{ml}^{-1}$ after 1st dose of lactose and $81.46 \text{ pg} \cdot \text{ml}^{-1}$ after 2nd dose of lactose) and decreased concentration of ALDO was observed ($77.69 \text{ pg} \cdot \text{ml}^{-1}$ after 1st dose of lactose and $70.64 \text{ pg} \cdot \text{ml}^{-1}$ after 2nd dose of lactose). On the basis of these results, it can be concluded that ANP and ALDO effectively respond to lactose load in 1-week-old calves.

Key words: calves, atrial natriuretic peptide, aldosterone, neonatal period, lactose

INTRODUCTION

The dynamic development of the body of calves in the first week of post-natal life entails changes in the activity of humoral factors involved in electro-

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lyte homeostasis. Important role in the regulation of sodium balance is played by atrial natriuretic peptide (ANP) and aldosterone (ALDO). ANP increases excretion of sodium and water with urine, ALDO acts antagonistically, increasing sodium reabsorption in kidney [Saito 2010, Cornelius et al. 2013]. Earlier studies have shown that the concentration of plasma ANP in 1-week-old calves is high while that of ALDO is low compared with adult [Dratwa 2006, Ożgo 2009]. At this early stage of life of calves, the opposite trend of changes in the concentrations of the active hormone antagonists is also observed: ANP level increases, while ALDO decreases with age.

High mortality is observed in the first month of life of calves. In most cases it is caused by impaired water-electrolyte balance due to severe dehydration resulting from diarrhea [Singh et al. 2009, Cho and Yoon 2014]. The pathogenesis of diarrhea can have different background: nutritional, zoohygienic or infectious [Dratwa-Chałupnik et al. 2012]. Overfeeding of calves with milk replacer leads to accumulation of lactose in the gastrointestinal tract and as consequence loss of water and electrolytes in the faeces [Olchoway et al. 1993, Górka and Kowalski 2007].

The loss of salt and resulting dehydration stimulates the body's endocrine system, which regulates water and electrolyte balance. Dehydrated animals have reduced concentration of plasma ANP [Bahner et al. 2007] and elevated concentration of ALDO [Safwate et al. 1991].

In the literature, there is scarce data on the effect of oversupply of milk replacer or an excessive amount of one of the milk replacer components on changes in the concentration of hormones that regulate water and electrolyte balance. Considering these facts, we have conducted a study to determine the effect of short term excess administration of lactose with milk replacer formulation on changes in the concentration of atrial natriuretic peptide and ALDO in the blood plasma of 1-week-old calves.

MATERIAL AND METHODS

The experiment was carried out on 8 Polish Holstein-Friesian var. Black-and-White male calves during the first week of life. They were fed colostrums until 3 days of age. From 4th day of life, animals were fed the milk replacer (Mlekovit Imupro[®], Polmass, Poland) twice a day in amount of 10% of body weight. Milk replacer contained 23% crude protein, 16% crude fat, 0.1% crude fibre, 45% lactose, 7.5% crude ash, 1.7% lysine, 0.42% methionine, 0.9% calcium, 0.7% phosphorus. Furthermore, the monohydrate lactose (Pharma Cosmetic, Poland) in amount $1 \text{ g} \cdot \text{kg}^{-1}$ body weight was added twice into the milk replacer: on the 6th day of life (during the evening feeding) and on the 7th day of life (during the mor-

ning feeding). The use and handling of animals for this experiment was approved by the Local Commission of Ethics for the Care and Use of Laboratory Animals (Resolution No. 3/2010).

Blood was drawn from the jugular vein into EDTA tubes before morning feeding from calves during 6th, 7th and 8th day of life. The samples were centrifuged (15 min, 4°C, 3000 rpm) and the harvested plasma was stored at -80°C until processing.

Plasma ANP concentration was measured using radioimmunoassay method with an iodine-125 radioimmunoassay kit (ANP, alpha 1-28, Phoenix Pharmaceuticals Inc. USA). The range of the standard curve was 10-1280 pg · ml⁻¹.

The level of ALDO was determined using an aldosterone ELISA kit (Aldosterone ELISA, Labor Diagnostika Nord, Germany). The range of the standard curve was 0-1000 pg · ml⁻¹.

Mean values and standard deviations were calculated. The resulting data were analysed by an ANOVA with repeated measurements. The significance of differences was tested with the Duncan post hoc test at the significance level $P \leq 0.05$ (Statistica, StatSoft Inc., Tulsa, OK, USA).

RESULTS

The average concentration of ANP in the blood plasma of calves during the study period was 80.94 pg · ml⁻¹. The lowest concentration of this hormone was observed prior to the addition of lactose to milk replacer (Fig. 1). After the application of the first dose of lactose, the average concentration of ANP increased. After the second dose, the average concentration of this hormone was higher than before the administration of lactose. However, these changes were not statistically significant. Significant individual differences were observed in the concentration of this hormone in the blood plasma of calves.

The average concentration of ALDO in the blood plasma of 1-week-old calves was 78.20 pg · ml⁻¹. After the first administration of lactose, a decrease was observed in the level of this hormone (Fig.1). After the second administration of lactose the average concentration of ALDO was statistically significantly lower ($P \leq 0.05$) than this observed prior to the administration of lactose to milk replacer.

DISCUSSION

The average concentration of the ANP in the blood plasma of tested calves was greater than that recorded in adults by Acosta et al. [2000]. Takemura et al.

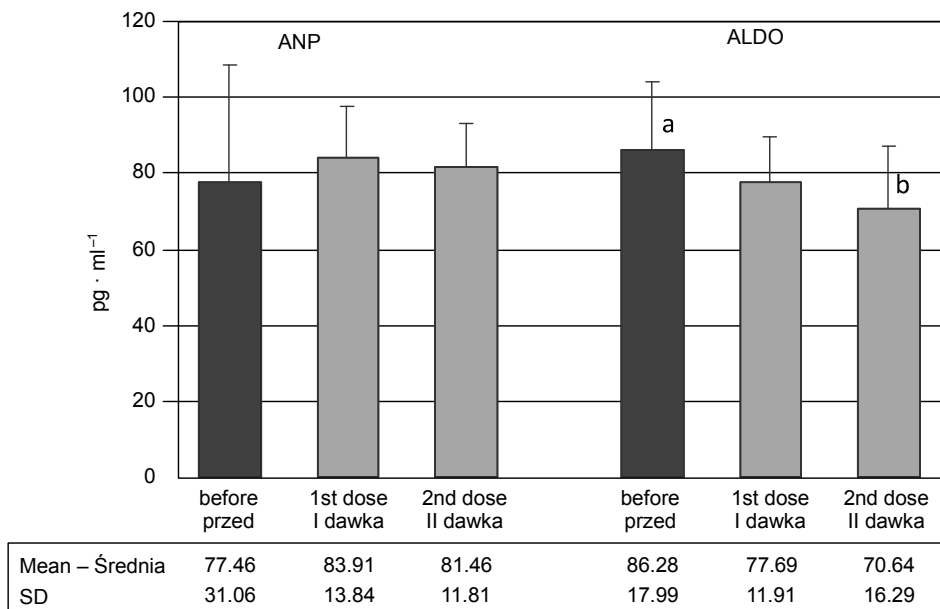


Fig. 1. Mean concentration of atrial natriuretic peptide (ANP) and aldosterone (ALDO) in the blood plasma of calves before and after supply of lactose (different lower-case letters indicate significant differences ($P \leq 0.05$) between the experimental periods)

Rys. 1. Średnie stężenie przedsionkowego peptydu natriuretycznego (ANP) i aldosteronu w osoczu krwi cieląt przed i po podaniu laktozy (różnymi, małymi literami zaznaczono znaczące różnice ($P \leq 0,05$) pomiędzy badanymi okresami)

[1994] observed the highest concentration of this hormone directly after the birth of calves ($62.7 \text{ pmol} \cdot \text{l}^{-1}$), and the lowest on the 10th day of life ($11.3 \text{ pmol} \cdot \text{l}^{-1}$).

Lack of statistically significant differences in concentrations of ANP after administration of lactose probably stems from the large individual differences in the concentration of this hormone in the calves studied. Interindividual differences in the level of blood ANP was also observed by Takemura et al. [1994] in calves, and by Ito et al. [1990] and Gemelli et al. [1991] in human newborns. However, after administration of lactose, the concentration of this hormone in the blood plasma of calves was higher than before the supply of excess lactose. Our previous studies [Dratwa 2006, Ożgo 2009] demonstrated an increase in the concentration of plasma ANP in calves with age, whereas the hormone level remained relatively stable in the 6th and 7th day of life. Presumably the increase in the concentration of ANP in the blood of examined calves occurred in response to increased sodium absorption from the gastrointestinal tract. Elevated supply of lactose and

high lactase activity, observed in 1-week-old calves [St. Jean et al. 1991], could have resulted in higher glucose concentration in the digestive tract, which triggered additional sodium absorption by glucose and sodium cotransporter. Atrial natriuretic peptide regulates sodium and water reabsorption not only in the kidney, but also in the gastrointestinal tract epithelium [Godellas et al. 1991]. Probably, elevated concentration of ANP in blood plasma in tested calves occurred in order to maintain stable quantity of sodium in the blood. ANP may regulate sodium balance by increase sodium excretion in the urine, as well as by inhibition of sodium absorption from the gastrointestinal tract. In consequence, stable sodium concentration was observed in the blood plasma of tested calves [Michałek et al. 2014].

In the current study, the average concentration of ALDO in the blood plasma of calves was higher than that recorded by Itoh et al. [1985] in 7-day-old calves ($67.00 \text{ pg} \cdot \text{ml}^{-1}$), and Amadiou et al. [1989] in 4-day-old calves ($60\text{--}70 \text{ pg} \cdot \text{ml}^{-1}$). However, significantly lower levels of this hormone were reported by Riad et al. [1986] in 10-day-old calves ($28.90 \text{ pg} \cdot \text{ml}^{-1}$). In addition, other researchers have found that the concentration of plasma ALDO of calves in the first week of life is lower than that of their mothers in the perinatal period [Safwat et al. 1991, Özgo 2001].

ALDO is the hormone responsible for regulating sodium balance in the body, which occurs either via the kidneys or colon [Jenkins et al. 1990, Palmer and Frindt 2000]. ALDO regulates sodium reabsorption and increases excretion of potassium in the colon [Jenkins et al. 1990, Singh et al. 2012]. Jenkins et al. [1990] demonstrated that the development of mechanisms responsible for sodium transport in the colon occurs much earlier than in the kidneys, which according to these authors, may indicate that the main organ responsible for the regulation of sodium in premature human neonates is the colon. Studies of Martinerie et al. [2009 and 2011] conducted in human and murine neonates indicated the physiological resistance of kidneys to ALDO, associated with reduced expression of receptors of this hormone in the kidneys at the time of birth. Furthermore, the aforementioned authors concluded that the development of ALDO receptors in human newborns takes about a year, which coincides with the maturation of renal function. Different observations were made by Safwate [1985]. This author showed that the renal tubules responded to ALDO infusion in 3-day-old calves.

In our study there was a significant decrease in ALDO concentration in calves' plasma after administration of lactose. The study of Özgo [2009] demonstrated that the concentration of ALDO in the blood plasma of calves gradually increased in the period from 2 to 7 days of age. Presumably the decreased of ALDO level in response to administration of lactose was to limit the sodium absorption in the colon, thereby to maintain a constant concentration of this electrolyte in the blood of calves.

CONCLUSIONS

According to Takemura et al. [1994], there is a relationship between the concentration of natriuretic and diuretic hormones in the blood of calves and antynatriuretic and antydiuretic hormone levels. The present study shows the opposite trend of changes of antagonistically acting hormones in response to administration of lactose with milk replacer formulation. On the basis of these results, it can be concluded that ANP and ALDO effectively respond to lactose load in 1-week-old calves.

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ODPOWIEDŹ NATRIURETYKA I ANTYNATRIURETYKA NA OBCIĄŻENIE LAKTOZĄ TYGODNIOWYCH CIELĄT

Streszczenie. Celem prezentowanych badań było określenie wpływu krótkotrwałego podawania nadmiaru laktozy wraz z preparatem mlekozastępczym na zmianę stężenia przedsionkowego peptydu natriuretycznego (ANP) oraz aldosteronu (ALDO) w osoczu krwi tygodniowych cieląt. Badania przeprowadzono na buhajkach rasy polskiej holsztyno- -fryzyjskiej odmiany czarno-białej. Zwierzęta karmione były dwukrotnie w ciągu dnia preparatem mlekozastępczym w ilości 10% masy ciała. Podczas wieczornego karmienia (pierwszego dnia doświadczenia) oraz podczas porannego karmienia (drugiego dnia doświadczenia) do preparatu mleko zastępczego dodano jednowodną laktozę w ilości $1 \text{ g} \cdot \text{kg}^{-1}$ masy ciała. W prezentowanych badaniach w odpowiedzi na podanie laktozy wraz z preparatem mlekozastępczym obserwowano przeciwstawną tendencję zmian antagonistycznie działających hormonów. Średnia koncentracja ANP przed podaniem laktozy wynosiła $77,46 \text{ pg} \cdot \text{ml}^{-1}$ a ALDO wynosiła $86,28 \text{ pg} \cdot \text{ml}^{-1}$. Po podaży laktozy zaobserwowano wzrost stężenia ANP ($83,91 \text{ pg} \cdot \text{ml}^{-1}$ po pierwszej dawce laktozy i $81,46 \text{ pg} \cdot \text{ml}^{-1}$ po drugiej dawce laktozy) oraz zmniejszenie stężenia ALDO ($77,69 \text{ pg} \cdot \text{ml}^{-1}$ po pierwszej dawce laktozy i $70,64 \text{ pg} \cdot \text{ml}^{-1}$ po drugiej dawce laktozy). Na podstawie uzyskanych wyników można stwierdzić, że ANP i ALDO skutecznie reagują na obciążenie laktozą tygodniowych cieląt.

Słowa kluczowe: cielęta, przedsionkowy peptyd natriuretyczny, aldosteron, okres neonatalny, laktoza

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