

RELATIONSHIP BETWEEN COLOSTRAL IMMUNITY AND BIOCHEMICAL STATUS IN NEONATAL CALVES

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A b s t r a c t

It is known that in animals with a desmochorial placenta, the unchanged colostral immunoglobulins enter the blood from the digestive tract for the first two days after birth, but remain the most active during the first hours of life. The passive transport of these immunoglobulins is influenced by various factors, including breed traits, housing conditions, the terms, amount and quality of colostrum intake. However, information about the effect of metabolic and antioxidant status of calves on the formation of colostral immunity is not complete until now. We studied the relationship between colostral immunity and biochemical status of newborn Red-and-White breed calves. The results of our investigations conclusively prove that the high level of magnesium and low values of calcium-magnesium ratio in the calves' serum lead to disruption of neuromuscular conduction and decrease muscle tone which are manifested through the later appearance and weakness of sucking reflex in animals. As a result, the volume of maternal colostrum is insufficient for the calves. The long-lasting (more than 48 hours) hypoxia and acidosis, and the increased toxic lipid peroxidation in neonatal calves cause a colostral immunoglobulin transport disorder. Protein and lipid oxidative modifications destruct the antibodies, circulating in newborn calves, and suppress the colostral immunity. In spite of the high level of humoral antibodies to bovine parainfluenza-3 and infectious bovine rhinotracheitis viruses antigens in cow-mothers, not all newborn calves are able to obtain the necessary colostral protection, as it is greatly affected by their metabolic and antioxidant status.

Keywords: newborn calves, colostral immunity, biochemical status, the system of antioxidant protection.

Colostrum immunity in animals with desmochorial placenta type establishes only at the expense of colostral antibodies entering through mucous tunic of the newborn's intestine. Colostral immunoglobulins enter out of digestive tract into blood unchanged during the first two days after birth but more actively during the first hours of life. It is known that passive transport of colostral immunoglobulins in newborn calves influences breed peculiarities [1], keeping conditions for animals [2, 3], terms, volume and quality of colostrum [3, 4]. However, the impact of calves' metabolic and antioxidant status on colostral immunity formation hasn't been studied enough yet.

The aim of this work was to study the connection between colostral immunity and biochemical status in calves during the first days of life.

Technique. The studies were held in 2011-2012 at Co Ltd "Voronezhpishcheprodukt" (Novousmanskiy Region, Voronezh Province) and included 30 newborn Red-Motley calves, which were divided into three groups after birth depending on blood serum content of total immunoglobulins. The animals got the first portion of colostrum in 1.0-1.5 h after birth. During

the first 1-3 days of life the calves were fed on colostrum every 6 h, since the 4th day – every 8 h. The animals were constantly clinically observed. Their body temperature, heart rate and respiratory rate per minute, state of visible mucous membranes, number of incisors, muscle tone, the time of sucking reflex and confident standing pose start, appetite were considered. Blood was sampled from calves' jugular veins during morning hours before feeding in 24 h after birth, on the 3rd, 7th and 14th days of life.

Blood serum content of total proteins was measured refractometrically, total immunoglobulins – according to the description [5], calcium and magnesium - on atomic adsorption spectrophotometer model 703 (“Perkin Elmer”, USA), activity of γ -glutamyl transferase (γ -GT) – on biochemistry analyzer Hitachi-902 (Japan). The amount of lactic and pyruvic acids in blood was determined by appropriate methods [6, 7]. To evaluate the intensity of lipid peroxidation (LPO) and antioxidant protection (AOP) system state, blood concentration of malonic dialdehyde (MDA), catalase and glutathione peroxidase (GPx) activity, total blood plasma antioxidant activity (AOA) were considered in calves [8].

Serological examinations of calves' and cow mothers' blood sera on the presence of antibodies specific to parainfluenza-3 (PI-3) and infectious rhinotracheitis (RT) viruses were realized with the use of commercial kits of erythrocytic diagnosticum (Co Ltd “Agrovet”, Moscow) in the reaction of indirect hemagglutination.

Experimental data processing was realized with the use of application statistical program Statistica v. 6.0. Significance of differences was evaluated by the method of pairwise comparisons using Student's t-criterion. The differences were considered reliable at significance level (error probability) of $p < 0.05$.

Results. Separation of the calves into the groups depends on blood serum concentration of total immunoglobulins in 24 h after birth. Group I included animals (n=13) with blood serum content of immunoglobulins lesser than 10 g/L (7.2 ± 0.86 g/L), group II (n=9) – from 10 to 15 g/L (12.4 ± 0.47 g/L), group III (n=8) – more than 15 g/L (18.9 ± 1.07 g/L). Blood serum concentration of total immunoglobulins in calves in 72 h after birth did not significantly change and was 7.7 ± 0.71 g/L in group I, 13.2 ± 0.36 and 19.3 ± 0.92 g/L in groups II and III, respectively.

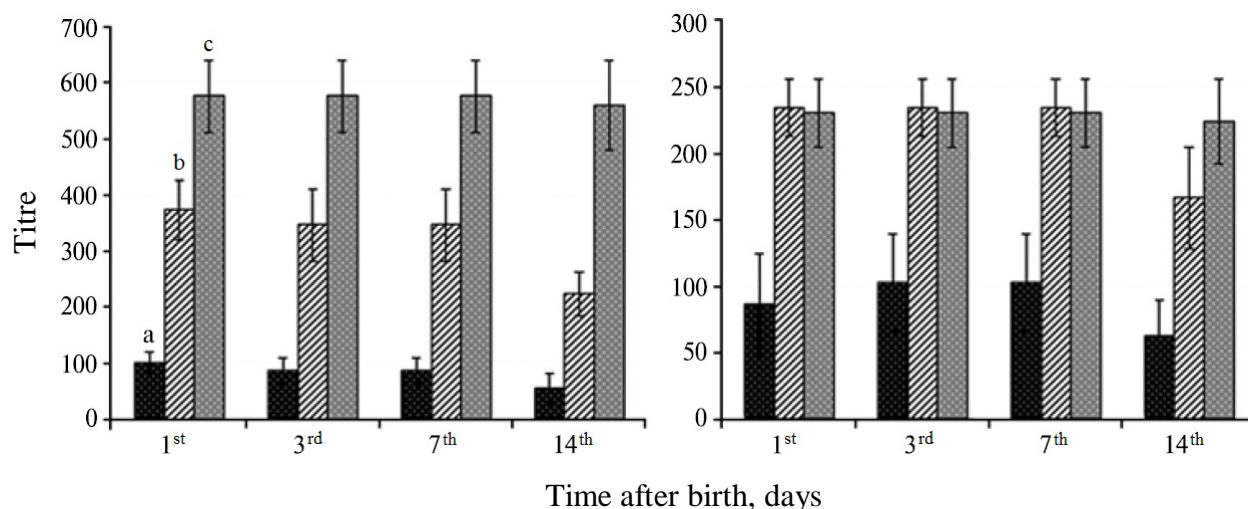


Fig. 1. Average titres of specific antibodies to parainfluenza-3 viruses (A) and infectious rhinotracheitis (B) in newborn Red-Motley calves: a, b, c – groups I, II and III, respectively (Co Ltd “Voronezhpishcheprodukt”, Novousmanskij Region, Voronezh Province, 2011-2012).

All the cows from which the calves were obtained demonstrated high content of PI-3 and RT virus antibodies in connection with planned immunization. There were revealed no significant differences in blood serum content of specific antibodies to antigens of PI-3 and RT viruses in cow mothers that delivered calves from different groups. Individual indices of blood

serum content of antiviral antibodies to PI-3 and RT in animals in all the cases were higher by 3-5 dilutions than a minimal diagnostic one. Average titres of antibodies to PI-3 and RT viruses in cow mothers of group I calves were 1:853 and 1:149, respectively, in group II – 1:512 and 1:230, group III – 1:768 and 1:230. However, not all the newborn calves obtained a necessary degree of colostral protection (fig. 1).

Content of colostral antibodies to PI-3 and RT viruses during 1-3 days of life was 2-6 times lower in calves of group I than in animals of groups II and III. Colostral antibodies to IP-3 virus in diagnostic titres of animals with blood serum content of total immunoglobulins lower than 10 g/L were revealed in 100% of cases (average titre of 1:86.7), to RT – in 80% of cases (average titre of 1:102.7). Content of specific antibodies to RT virus did not significantly change in calves of group II in comparison with calves of group III. Content of specific antibodies to IP-3 virus was by 35-40% lower in calves of group II in comparison with calves of group III.

There were significant differences in time of sucking reflex and confident standing pose start in the newborns of different groups. So, confident standing pose start in group I was registered in 49.9±3.30, in groups II and III – in 34.0±0.55 and 29.8±1.55 min after birth. Sucking reflex start in calves of group I was registered in 42,1±3,20 min after birth, in animals of groups II and III – in 28.0±0.63 and 26.8±0.75 min, respectively. As far as for the calves during the first days of life colostrum is a single natural source of specific antibodies to the pathogens circulating among animals colostral immunity of the newborn directly depends on the quality of maternal colostrum, time of start and intensity of sucking reflex [3, 4]. It is known that muscle tone and regulation of neuromuscular transmission in the newborn are connected with calcium and magnesium content and their blood ratio [9, 10].

1. Calcium and magnesium content and blood serum ratio in newborn Red-Motley calves according to the groups ($X\pm x$, Novousmanskij Region, Voronezh Province, 2011-2012)

Index	Group of calves		
	I (n = 13)	II (n = 9)	III (n = 8)
Calcium, mmol/L	2.89±0.05	3.14±0.15	2.91±0.11
	2.83±0.02	2.93±0.15	3.09±0.13
Magnesium, mmol/L	1.01±0.03*	0.99±0.06*	0.77±0.05
	0.97±0.02*	0.87±0.03*	0.78±0.04
Calcium-magnesium ratio	2.89±0.11*	3.22±0.06*	3.73±0.14
	2.93±0.07*	3.35±0.10*	3.95±0.02

Note. Above the line – indices on the 1st day of life, under the line – indices on the 3rd day of life. Description of the groups according to total immunoglobulin content in 24 h after birth. See the text.
* p < 0.05 in comparison with the indices of group III.

According to our data calcium blood serum concentration in calves at the age of 1 day according to the groups did not significantly differ, magnesium concentration was higher in animals of groups I and II than in group III (by 31.2 and 28.6% (p < 0.05), respectively). Increased blood serum concentrations of magnesium to a considerable degree are connected with hypoxia and acidosis states in the newborn [10]. The presence of oxygen deficit in calves of group I was proved by high blood content of lactic acid exceeding average indices in animals of groups II and III by 51.3 and 83.1 % (p < 0.05), respectively. Calcium-magnesium ratio in calves of group I was by 10.2 and 22.5% lower (p < 0.05) than in animals of groups II and III, respectively. Calcium-magnesium ratio decreased in animals of group II by 13.7% (p < 0.05) than in animals of group III. The same dependence reserved on the 3rd day of life.

Correlation analysis revealed the presence of statistically significant correlations between blood serum calcium-magnesium ratio at the age of one day and the time of sucking reflex start (r = - 0.39, p < 0.05) and confident standing pose start (r = -0.37, p < 0.05) in calves. Significant correlation of calcium-magnesium ratio with blood serum content of total immunoglobulins (r = + 0.41, p < 0.05) and lactic and pyruvic acids blood content ratio (r = -0.41, p < 0.05) on the 3rd day of life.

2. Blood serum state of LPO-AOP system in newborn Red-Motley calves according to the groups ($X\pm x$, Novousmanskij Region, Voronezh Province, 2011-2012)

Index	Group of calves
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	I (n = 13)	II (n = 9)	III (n = 8)
MDA, $\mu\text{mol/L}$	$1.44 \pm 0.15^*$ $1.57 \pm 0.16^*$	$1.77 \pm 0.19^*$ $1.90 \pm 0.15^*$	1.16 ± 0.10 1.12 ± 0.12
Catalase, $\mu\text{mol/L H}_2\text{O}_2/(\text{L} \times \text{min})$	25.18 ± 0.86 $24.36 \pm 0.38^*$	24.81 ± 0.57 $25.01 \pm 1.05^*$	26.96 ± 2.43 32.67 ± 2.10
GPx, $\text{mmol GSH/L} \times \text{min}$	$7.33 \pm 0.25^*$ $7.76 \pm 0.21^*$	$7.09 \pm 0.18^*$ 8.02 ± 0.58	8.06 ± 0.20 8.21 ± 0.06
AOA, %	$37.00 \pm 2.40^*$ $38.30 \pm 3.60^*$	$42.00 \pm 2.10^*$ $44.70 \pm 1.50^*$	47.50 ± 0.90 50.30 ± 1.30

Note. LPO, AOP, MDA, GPx, AOA – lipid peroxidation, antioxidant protection, malonic dialdehyde, glutathione peroxidase, antioxidant activity. Above the line – indices on the 1st day of life, under the line – indices on the 3rd day of life. Description of the groups according to blood serum total immunoglobulin content in 24 h after birth. See the text.
* $p < 0.05$ in comparison with the indices of group III.

Lactic and pyruvic acids blood content ratio was higher in calves of group I in 72 h after birth than in animals of groups II and III by 62.2 and 90.2% ($p < 0.05$), respectively. The analyzed index in calves of group II at the same age exceeded the same index in animals of group III by 17.2% ($p < 0.05$). The conditions for realization of oxidative reaction on the acidosis-dependent mechanism with the formation of toxic derivatives arise under evident hypoxia and acidosis that is proved by increased lactic acid content and lactic and pyruvic acids blood ratio [11, 12]. So, blood content of MDA in animals of groups I and II on the 3rd day of life appeared to be higher than in calves of group III by 40,2 and 69,6% ($p < 0,05$), respectively. At the same time catalase blood activity in animals of groups I and II decreased relatively to the index in group III by 25.4 and 23.4%, antioxidative blood plasma activity – by 23.9 and 11.1% ($p < 0.05$), respectively (tab. 2).

The intensity of colostrum immunoglobulin absorption from intestine was evaluated by the activity of γ -glutamyl transferase in calves' blood serum [13]. This index in animals of group I at the age of 1 day was 4.39 and 9.01 times ($p < 0.05$) lower in comparison with the animals of groups II and III, respectively, in calves of group II – 2.05 times lower ($p < 0.05$) than in animals of group III. Blood serum enzymatic activity naturally decreased in all the calves on the 3rd day of life (fig. 2). At the same time it was 445.1 ± 4.7 U/L in animals of group III. It was 2.20 and 8.76 times ($p < 0.05$) lower in animals of groups II and III.

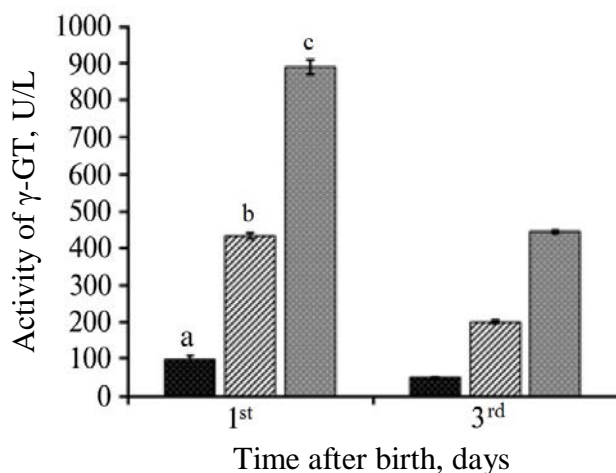


Fig. 2. Blood serum activity of γ -glutamyl transferase (γ -GT) in newborn Red-Motley calves: a, b, c – groups I, II and III, respectively (Novousmanskiy Region, Voronezh Province, 2011-2012).

The data obtained corresponds with the results of other studies [12, 14] and proves that transport of colostrum immunoglobulins and formation of passive immunity are disturbed in newborn calves under acidosis conditions and excessive accumulation of LPO toxic products in the organism.

So, the increase of magnesium content and decrease of calcium-magnesium blood ratio in newborn calves lead to the disorders of neuromuscular transmission and muscle tone that manifests itself by a later sucking reflex start, its weak evidence and is a cause for insufficient

feeding of maternal colostrum. The disorders of transport of colostral immunoglobulins out of intestine appear in newborn calves under conditions of prolonged (more than 48 h) hypoxia and acidosis and increased formation of lipid peroxidation toxic products. Oxidative modification of proteins and lipids leads to the damage of molecular structure of antibodies circulating in the organism and disorders of colostral immunity formation.

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