Age-Dependent Level of Antioxidant Defense System and Lipid Metabolism State in Calves

Nikolai A. Kostromitinow, PhD

Pharmacological Laboratory of the Institute of Experimental Veterinary Medicine
Moscow, Russia

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ABSTRACT

The findings obtained in the present study showed that the first days of life of the calves up to Day 45 are accompanied by the naturally determined increase in the trenbolone acetate-active products and glutathione, which, in our opinion, is related to the transition period in feeding of the calves. The content of phospholipids and lipoproteins in blood of animals increases by Day 30 and then stabilizes. The enzymatic activity of blood from Day 5 to Day 30 changes in a different manner. Thus, the catalase and ceruloplasmin values were noted to decrease by Day 30, followed by an increase in and stabilization of the concentration of the enzymes by Day 45–60. In contrast, the peroxidase value is steadily decreasing in the age-related dynamics although we registered the lowest index by Day 30 of the calves' life.

INTRODUCTION

Amongst various classes of lipid metabolism reactions, the lipid peroxidation processes not only play an important part in the normal physiology and biochemistry of the cell but also present as a versatile nonspecific link of mechanisms of development of various pathophysiological states. Depending on the intensity and duration of the body-influencing factors of physical, chemical, and biological nature, changes in regulation of the lipid peroxidation reactions may well be reversible, with a subsequent return to the norm.[1,2]

The intensity of lipid peroxidation processes and functional power of the antioxidant system of the body are species-specific, to be predetermined by the evolutionally conditioned peculiarities. The alterations in the antioxidant defense system of the body and intensity of lipid peroxidation processes are intrinsic components of the systemic reaction to such factors of environmental exposure as stresses, carcinogenic agents and substances, radionuclides, pathogenic microorganisms, etc. Free-radical oxidation itself is known to be a chain process.[3,4]

The current study was aimed at examining the free-radical lipid oxidation processes and determining the physiological norm of the basic indices of lipid peroxidation and the antioxidant defense system in animals.

MATERIALS AND METHODS

The work was performed at the Pharmacological Laboratory of the Institute of Experimental Veterinary Medicine, Moscow, Russia. The studies were carried out in calves on Days 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, and 60 (N = 25).

The blood-contained substances studied were as follows: glutathione,[5] peroxidase K.F. 1.11.1.7,[6] thiobarbituric acid/MDA,[7]

Table 1. Contents of TBA-Active Products in Blood

Age of Calf (Days) (N = 25)	Thiobarbituric Acid (µm/L)	Catalase (µM H_2O_2/L × min)	Peroxidase (units of optic sec)	Ceruloplasmin (benzo-quinone/L min)	Factor $p < 0.05$ Glutathione (mM/L) All	Revoit	Oxidized	Oxidized/ Revoit	Revoit/ All	Phospholipids (mol/L)	β-Lipoproteins (mg%) All	Album	Lipids
5	2.11 ± 0.1	36.63 ± 8.18	51.52 ± 11.52	243.4 ± 53.43	2.56 ± 0.12	1.56 ± 0.34	0.99 ± 0.21	0.63	0.6	162.12 ± 36.25	547.08 ± 122.3	114.68 ± 25.64	432.4 ± 16.69
10	2.10 ± 0.18	11.06 ± 2.03	59.35 ± 10.88	283.3 ± 51.9	3.5 ± 0.09	2.58 ± 0.47	0.92 ± 0.38	0.8	0.73	105.7 ± 19.38	490.82 ± 89.96	102.88 ± 18.86	387.9 ± 11.1
15	4.31 ± 0.1	16.2 ± 11.5	49.98 ± 35.4	170 ± 120	1.88 ± 1.3	1.27 ± 1.1	0.6 ± 0.4	0.48	0.67	173 ± 122.1	430 ± 305.1	90.28 ± 64.0	340.4 ± 241.1
20	1.27 ± 0.3	14.08 ± 3.52	49.58 ± 12.4	207.5 ± 51.87	1.75 ± 0.44	1.35 ± 0.34	0.39 ± 0.1	0.29	0.77	185.8 ± 46.45	707.13 ± 176.78	148.23 ± 37.06	558.9 ± 13.73
25	1.69 ± 0.31	12.23 ± 2.26	37.19 ± 6.82	137.16 ± 25.14	2.02 ± 0.37	1.44 ± 0.26	0.58 ± 0.11	0.4	0.71	181.05 ± 33.16	628.56 ± 128.8	131.76 ± 27.0	496.8 ± 10.8
30	3.61 ± 0.21	10.93 ± 3.1	48.84 ± 7.12	120.7 ± 11.2	2.41 ± 0.21	1.73 ± 0.09	0.68 ± 0.23	0.39	0.71	242 ± 15.6	989.4 ± 56.7	207.4 ± 17.4	782 ± 58.7
35	2.5 ± 0.12	27.39 ± 0.12	10.92 ± 0.5	242.4 ± 22.3	1.72 ± 0.25	1.43 ± 0.21	0.28 ± 0.15	0.19	0.83	159.14 ± 11.76	695 ± 11.9	145.6 ± 6.42	549.2 ± 7.17
40	3.22 ± 0.13	28.6 ± 0.29	16.24 ± 0.91	205 ± 54.7	2.1 ± 0.15	1.39 ± 0.19	0.69 ± 0.21	0.52	0.66	147.2 ± 10.8	687 ± 12.6	143.9 ± 6.9	542.8 ± 4.89
45	3.48 ± 0.22	23.73 ± 0.22	11.7 ± 0.11	213.3 ± 34.2	1.05 ± 0.11	0.65 ± 0.12	0.43 ± 0.12	0.61	0.61	138.5 ± 14.9			
50	0.78 ± 0.005	23.82 ± 5.16	13.75 ± 1.06	250 ± 13.4	1.46 ± 0.16	1.31 ± 0.23	0.65 ± 0.03	0.11	0.89	174.5 ± 1.92	736.2 ± 4.78	154.3 ± 1.02	581.8 ± 3.78
55	0.96 ± 0.09	24.5 ± 4.9	21.13 ± 2.04	340 ± 12.5	1.49 ± 0.42	0.88 ± 0.14	0.61 ± 0.01	0.16	0.85	175 ± 0.9	704.2 ± 5.83	147.6 ± 1.41	556.6 ± 3.26
60	0.99 ± 0.058	26.34 ± 0.87	16.34 ± 0.87	290 ± 10.7	1.46 ± 0.55	0.89 ± 0.05	0.57 ± 0.11	0.41	0.7	101 ± 1.45	753.6 ± 4.97	157.9 ± 0.94	597.7 ± 1.04

catalase K.F. 1.11.1.6,[8] ceruloplasmin,[9] phospholipids,[10] and lipoproteins.[11]

RESULTS

The age-related dynamics of the trenbolone acetate (TBA)-active products (malonic dialdehyde) was characterized by a significant increase in the level in calves under 15 days old from 2.11 to 4.31 µM/L, followed by a decrease to 1.27 µM/L on Days 20-25. This parameter was noted to rise again to 3.22–3.38 µM/L at the age of 30-45 days. In 50-to-60-day-old calves, the content of TBA-active products in blood stabilizes ranging from 0.78 to 0.99 µM/L (Table 1). The obtained findings showed that the level of lipid peroxide metabolites (TBA-active products) is rather high from the first days of life until the age of 45 days. This was probably related to the formation and development of the immune system and non-specific resistance system in the animals. The 50-to-60-day-old calves were observed to have a low and reliably stable content of TBA-active products in blood.

The main function of the antioxidant defense system is to maintain the concentration of free radicals and oxygen active forms in the animals at a stable level. Thus, catalase is known to cleave oxygen radicals (to which superoxide dismutase dismutates the superoxide radical) to the molecules of water and molecular oxygen. In cells, catalase is mainly concentrated in peroxisomes also containing enzymes producing oxygen peroxide required in the course of a series of the processes of the body's vital functions, in particular, in the processes of non-specific immune defense. The catalase value during the first days of life in 5-day-old calves appeared to be high, amounting to 36.63 µM H_2O_2/L × min, then decreasing to 10.93 µM H_2O_2/L × min from Day 10 until Day 30. From Day 35 to Day 60 of the study, the catalase value stabilizes to the range 23.73–26.34 µM H_2O_2/L × min.

Peroxidase is widely distributed in animal cells and localized in the cytosol and mitochondrial matrix. The enzymatic activi-

ty of peroxidase in blood of calves is age-dependent, initially present at a sufficiently high level (51.52–48.84 units of optic density/L sec) in 5-to-30-day-old claves and decreasing thereafter and stabilizing to 10.92–16.34 units of optic density/L sec.

Ceruloplasmin is a copper-containing α-globulin of blood plasma, performing a wide variety of important biological functions in the body: increases stability of cellular membranes, participates in immunological reactions, ion exchange, exerts an antioxidant effect (preventing cellular-membranes lipid peroxidation), and stimulates hemopoiesis. The content of ceruloplasmin in blood plasma of the calves is sufficiently stable, ranging from 243 to 290 benzoquinone/L min, although somewhat decreasing on Days 15, 25, and 30 to 120.7–170 benzoquinone/L min.

The glutathione system appears to occupy a highly important place in the system of antiradical defense. This system participates in maintaining the disulfide balance, influencing the activity of enzymes, regulating carbohydrate, lipid, and protein metabolism, and being capable of regulating the properties and functions of biological membranes, as well as influencing biosynthesis of DNA and proteins. This underlines its most important role in maintaining cellular homeostasis. During the first days of life in 5- and 10-day-old calves, glutathione amounts to 2.56 and 3.5 mM/L, respectively. On Days 15 and 20, it then decreases to 1.88 and 1.75 mM/L, respectively. By Days 25 and 30 of the calves' life, the glutathione value increases to 2.02 and 2.41 mM/L. It stabilizes in 35 days, amounting to 1.05–1.26 mM/L.

Lipids and proteins are known to be the basic components of the cellular membrane. The lipid layer of the cellular and intracellular membranes performs 2 main functions: barrier and matrix (structural). In the normally functioning cell, the medial part of the lipid layer is an integral film formed by hydrocarbon tails of phospholipid molecules. Damage to this integral barrier gives rise to disordered regulation of intracellular processes and severe cellular dysfunctions. On Day 30, the content of phospholipids and lipoproteins in blood of the calves was the highest, amounting to 242 mol/L and 989.4 mg%, respectively. These indices then decrease and stabilize by Day 60 amounting to 753.6 mg%.

DISCUSSION

The findings obtained in the present study showed that the first days of life of the calves up to Day 45 are accompanied by the naturally determined increase in the TBA-active products and glutathione, which, in our opinion, is related to the transition period in feeding of the calves. The content of phospholipids and lipoproteins in blood of animals increases by Day 30 and then stabilizes. The enzymatic activity of blood from Day 5 to Day 30 changes in a different manner. Thus, the catalase and ceruloplasmin values were noted to decrease by Day 30 followed by an increase in and stabilization of the concentration of the enzymes by Days 45 to 60. In contrast, the peroxidase value is steadily decreasing in the age-related dynamics, although we registered the lowest index by Day 30 of the calves' life.

CONCLUSIONS

We determined a sharp increase in the lipid-peroxidation secondary metabolites up to the age of 45 days. The enzymatic activity of catalase and ceruloplasmin decreases by Day 30, increasing thereafter to remain at the stationary concentration until Day 60. The peroxidase index has an age-dependent tendency to decrease. The content of phospholipids and lipoproteins in blood increases by Day 30, then decreases significantly and remains at a fixed level. Hence, the obtained findings may be used for studying the general physiological status of animals.

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