Age-dependent Level of Antioxidant Defence System and Lipid Metabolism State in Calves

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ABSTRACT

The findings obtained in the present study show that the first days of life of calves, up to day 45, are accompanied by a naturally determined increase in TBA (thiobarbituric acid)-active products and glutathione. In our opinion, this is related to the transition period in feeding of the calves. The blood content of phospholipids and lipoproteins in animals increases by day 30 and then stabilizes. On the other hand, 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 and stabilization of the concentration of the enzymes by days 45-60. In contrast, the peroxidase value steadily decreases in the age-related dynamics. The lowest index was registered by day 30 of the calves' life.

INTRODUCTION

Among 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, non-specific link for 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. (S.W. Edwards at all. 1982; C.Calwda 1993).

The intensity of lipid peroxidation processes and functional power of the antioxidant system of the body are species-specific, to be predetermined by evolutionally conditioned peculiarities. The alterations in the antioxidant defence 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. (P.H. Chan 1994; E.D. Harris 1992).

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

MATERIALS AND METHODS

The study was performed at the Pharmacological Laboratory of the Institute of Experimental Veterinary Medicine, Moscow, Russia. Tests were carried out in calves on

days 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55 and 60 (n = 25).

The biochemid parameters studies of the blood (plasma) were: glutathione (J. Sedlak R.H.Lindsay 1968), peroxidase K.F. 1.11.1.7 (B.Pleshanov 1977), thiobarbituric acid / TBA (M. Mihara at all 1980), catalase K.F. 1.11.1.6. (M. Koroluk at all 1988), ceruloplasmin (E. Ten 1981), phospholipids (H. Oliver 1994), lipoproteins (M. Ledvina 1960) (Method statistic analyse H. Bancroft 1957).

RESULTS

The age-related dynamics of the TBA (thiobarbituric acid)-active products (malonic dialdehyde) were 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 day 20-25. This parameter rose again to 3.22 – 3.38 μM/l at 30 – 45 days. In 50-to-60-day-old calves, the content of TBA (thiobarbituric acid)-active products in blood stabilized ranging from 0.78 to 0.99 μM/l (see the Table). These findings showed that the level of LPO metabolites (TBA-active products) was high in 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 their blood.

The main function of the antioxidant defence system is to maintain the concentration of free radicals and oxygen active forms at a stable level. Thus, catalase is known to cleave oxygen radicals (to which superoxide dismutase dismutates the superoxide radical) to molecules of water and molecular oxygen. In cells, catalase is mainly concentrated in peroxisomes. They also contain oxygen peroxide-producing enzymes required for many of the body's vital functions. In particular, they are necessary for the processes of non-specific immune defence. The catalase value in 5-day-old calves appeared to be high, amounting to 36.63 μM H2O2/l × min, then decreasing from day 10 through 30 to 10.93 μM H2O2/l × min. From day 35 to day 60 of the study, the catalase value stabilized to a range within 23.73 – 26.34 μM H2O2/l × min.

Peroxidase is widely distributed in animal cells, localized in the cytosol and mitochondrial matrix. The enzymatic activity of peroxidase in calf blood is age-dependent. In the 5-to-30-day-old claves, it is at a relatively high level (51.52 – 48.84 units of optic density/l sec), decreasing thereafter and stabilizing within the range of 10.92-16.34 units of optic density/l sec.

Ceruloplasmin is a copper-containing α-globulin of blood plasma which performs a wide variety of important biological functions. These include: increasing stability of cellular membranes, participating in immunological reactions, involvement in ion exchange, exerting an antioxidant effect (preventing cellular membranes' lipid peroxidation), and stimulating haemopoiesis. The content of ceruloplasmin in the blood plasma of calves was sufficiently stable, ranging from 243 to 290 benzoquinone/l min, although it somewhat decreased during days 15, 25 and 30, amounting to 120.7 – 170 benzoquinone/l min.

The glutathione system appears to occupy an important place in the system of antiradical defence. This system is involved with: maintaining the disulfide balance, influencing the activity of enzymes, regulating carbohydrate, lipid and protein metabolism, regulating the properties and functions of biological membranes, and influencing biosynthesis of DNA and proteins. This underlines its most important role, which is maintaining cellular homeostasis. Glutathione in 5- and 10-day-old calves amounted to 2.56 and 3.5 mM/l, respectively. On day 15 and 20, it decreased to 1.88 and 1.75 mM/l, respectively. By days 25 and 30, the glutathione value increased to 2.02 and 2.41 mM/l. It stabilized at 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 two main functions. It is both a matrix (structural) and a barrier. In the normally functioning cell, the medial part of the lipid layer is a film formed by hydrocarbon tails of phospholipid molecules. Damage to this integral barrier gives rise to disorder in intracellular processes, and to severe cellular dysfunctions. On day 30, the content of phospholipids and lipoproteins in the calves' blood was the highest, amounting to 242 mol/l and 989.4 mg%, respectively. Then, these indices decrease and stabilize by day 60, amounting to 753.6 mg%.

DISCUSSION

The findings obtained in the present study show that the first days of life of calves, up to day 45, are accompanied by a naturally determined increase in the TBA-active products and glutathione. In our opinion, this process is related to the connecting period of feeding of calves. The content of phospholipids and lipoproteins in the blood increases by day 30 and then stabilizes. However, enzymatic activity of blood from day 5 to day 30 changes in a different manner. 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 steadily decreases. The lowest index was registered 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 decreased by day 30, increasing thereafter to remain at the stationary concentration till day 60. The peroxidase index had an age-dependent tendency to decrease.

The content of phospholipids and lipoproteins in blood increases by day 30, then decreases significantly and remains within a constant range.

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