ROLE OF CHEMORECEPTORS IN REFLEX REGULATION OF BLOOD LEVELS OF SOME TRACE ELEMENTS

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Experiments on cats anesthetized with urethane showed that stimulation of chemoreceptors of the small intestine, isolated from the circulatory system after retaining its nervous connections, causes an increase in the blood concentrations of iron and zinc and a decrease in the copper concentration. The carbonic anhydrase activity and iron saturation of the serum transferrin are increased, while the ceruloplasmin activity is lowered.

Stimulation of the receptors of various internal organs is accompanied by marked changes in the blood levels of glycogen, glucose, and lactic acid; changes also take place in the composition of the protein fractions and enzyme activity of the blood [1-7, 9, 10, 12]. In response to interoceptive stimulation, changes are also observed in the concentrations of mineral components of the blood: trace elements, calcium, potassium, magnesium, chlorine, sulfur, and phosphorus [10-11].

Changes in the blood levels of trace elements during interoceptor stimulation have received little study. Data in the literature refer only to changes in the concentrations of some trace elements (copper, titanium, manganese, etc.) in the blood of animals during stimulation of the mechanoreceptors of the stomach and rectum [7, 11, 14, 15]. No reports of combined investigations to determine the concentrations of trace elements and of enzymes activated by them, in response to stimulation of receptors of the internal organs, could be found in the literature. Yet the reflex regulation of trace element metabolism is an important aspect of the problem of elucidation of their biological role.

The object of the present investigation was to study the concentrations of iron, copper, and zinc and the activities of their conjugated metalloproteins (transferrin, ceruloplasmin, carbonic anhydrase) in the blood and serum during stimulation of the chemoreceptors of the small intestine.

EXPERIMENTAL METHOD

Experiments were carried out on adult male cats anesthetized with urethane (1 g/kg, intraperitoneally).

The small intestine (except the duodenum and a small area of jejunum adjacent to it) was isolated from the circulatory system and perfused with oxygenated Tyrode solution heated to 37-38°; the nerve supply to the intestine was preserved [16]. The chemical stimulus (acetylcholine) was applied to the receptors of the intestinal loop through a cannula inserted into the mesenteric artery, and it was rinsed out with a current of perfusion fluid through the anterior mesenteric vein.

The functional state of the chemoreceptors was tested by determining the intensity of the pressor vascular reflexes to acetylcholine, recorded on a kymograph by a mercury manometer.

Since the body level of the trace elements varies with the time of day and night [4, 9], the experiments were all performed at the same time, on fasting animals. Blood for testing was taken from the femoral artery before and 1-5 min after acetylcholine was injected into the vessels of the perfused intestinal loop.

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To determine the blood levels of copper and iron and also the ceruloplasmin (copper oxidase) activity and the transferrin iron saturation of the blood serum, the colorimetric method of Babenko [2, 3, 5] was used. The zinc concentration in the blood was determined by a polarographic method. Carbonic anhydrase activity was determined by Vendt's method.

Altogether 22 experiments were carried out. The numerical results were analyzed by statistical methods.

EXPERIMENTAL RESULTS

Injection of acetylcholine (10 μg) into the intestinal vessels caused the blood iron concentration to increase from 47.9 to 57.2 mg%, i.e., on the average by 21 ± 6.9% ($P < 0.05$), while the iron saturation of transferrin (a metalloprotein concerned with the transfer of iron from the blood to various organs and depots of the body) in the blood serum rose from 0.23 to 0.31 conventional unit (by 36 ± 3.6%; $P < 0.01$). The blood zinc concentration rose after injection of acetylcholine into the vessels of the intestinal loop from 0.624 to 0.843 mg% (by 35 ± 9.5%; $P < 0.01$), while the activity of the zinc-containing enzyme carbonic anhydrase in the blood rose from 0.82 to 1.23 Krebs unit, i.e., by 51 ± 7.1% ($P < 0.01$).

Meanwhile the action of acetylcholine on the intestinal receptors led to a decrease in the blood copper concentration from 0.32 to 0.27 mg% (by 19.7 ± 5.6%) and to a decrease in activity of the copper-containing enzyme ceruloplasmin from 35.4 to 31.7 conventional units (by 10.4 ± 3.9%; $P < 0.05$).

Control investigations showed that perfusion of the intestinal loop with Tyrode solution itself could cause changes in the concentrations of those traceselements and activities of the metalloenzymes in the blood, although these changes were not statistically significant. The most marked changes were observed in the iron concentration; the blood iron concentration was reduced after perfusion with Tyrode solution for 15 min on the average by 4.63 ± 2.62 mg% ($P > 0.05$). Under these conditions the iron saturation of the serum transferrin fell from 0.25 to 0.22 conventional unit. The copper concentration and ceruloplasmin activity in the blood fell by 4.6 ± 3.2 and 8.8 ± 5.2% respectively ($P > 0.05$). Changes in the zinc concentration and carbonic anhydrase activity likewise were not statistically significant.

Stimulation of the chemoreceptors of the small intestine is thus followed by definite changes in the concentrations of certain trace elements and in the activity of their conjugated metalloenzymes in the blood of animals.

The changes observed in the concentrations of these trace elements must be attributed both to their redistribution between the tissue depots (liver and other organs) and the blood, and also to changes in hematopoiesis in the body resulting from stimulation of the interoceptors [8, 17]. Another possibility is that the decrease in copper concentration and copper-oxidase activity in the blood during stimulation of the interoceptors takes place through a decrease in the content of protein fractions of the blood and liver, especially of α_2-globulins [1], the structural basis of copper oxidase.

The results described above demonstrate the importance of interoceptive afferent influences in the regulation of metabolism of trace elements and metalloenzymes, which play an important role in tissue respiration, gas exchange, hematopoiesis, and other physiologically important functions.

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