COPPER METABOLISM IN DOGS AFTER TOTAL AND PARTIAL GASTRECTOMY (THE PATHOGENESIS OF AGASTRIC HYPOCHROMIC ANEMIAS)

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According to reports in the literature [3, 7, 18], copper catalyzes the conversion of the inorganic iron of the food into an organically bound form, and thus plays an important role in the synthesis of hemoglobin and other porphyrins, thereby providing theoretical justification for the successful use of copper and iron preparations for the treatment of patients with anemia [10, 12, 14, 16].

Because in some cases resection of the stomach disturbs the processes of hemopoiesis and causes the development of a pathological state known as "agstric asthenia" [1, 2, 4-6, 8, 9, 13, 15, 17], there appeared to be a need for an experimental study of trace element metabolism after resection of various parts of the stomach.

The present paper describes the results of a study of changes in the copper concentration in whole blood and blood ultrafiltrates and also in the organs and tissues of experimental dogs.

EXPERIMENTAL

Experiments were carried out on dogs undergoing the following operations: gastrectomy followed by esophago-jejunostomy, the Billroth II resection of the pyloro-duodenal portion of the stomach, and segmental resection of the body of the stomach. Control animals underwent laparotomy. Copper was determined quantitatively by G. A. Babenko's colorimetric method [3].

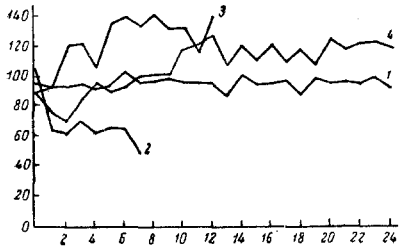

Fig. 1. Dynamics of copper concentration in whole blood. 1) Laparotomy (control); 2) gastrectomy; 3) removal of pyloro-duodenal portion of the stomach; 4) segmental resection of the body of the stomach. Abscissa—months after operation; ordinate—copper concentration (in μg/100 ml blood).

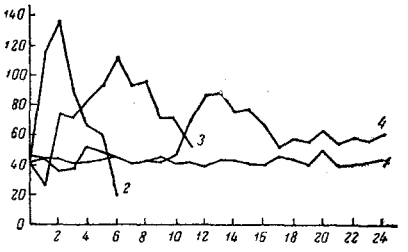

Fig. 2. Dynamics of copper concentration in ultrafiltrates of blood. Ordinate—copper concentration (in μg/100 ml ultrafiltrate). Remainder of legend as in Fig. 1.

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EXPERIMENTAL RESULTS AND DISCUSSION

Observations on the animals in the postoperative period showed that, despite a balanced diet, their body weight fell progressively and the animals died 6-9 months after gastrectomy and 10-12 months after resection of the body of the stomach lost less weight and survived for more than two years.

Regular changes were found in the copper concentrations in whole blood (Fig. 1) and ultrafiltrates of blood (Fig. 2), and also in the organs and tissues of the animals undergoing these operations (see table).

Analysis of the indices of copper metabolism in the animals of each series and comparison with the blood picture [11] yielded the following results.

In the animals of the control group the mean copper concentration in whole blood before the operation was 95 μg%, and in the ultrafiltrates 41 μg%. In the early (10-20 days) and late (12-24 months) periods after the operation the copper concentration in the whole blood and blood ultrafiltrates remained practically unchanged. The copper concentrations in the organs and tissues of these animals corresponded to their level in healthy animals.

In the dogs undergoing gastrectomy, the mean copper concentration in the whole blood before the operation was 102 μg% and in the ultrafiltrates 40 μg%. The gradual deterioration in the general condition of the animals and the development of hypochromic anemia was accompanied by marked changes in the copper concentration in the blood and organs. In the whole blood (Fig. 1, 2), for instance, during the first months and in the subsequent stages after the operation, the copper concentration fell to 65 μg%(m±5.6; $P < 0.01$). The changes in the copper concentration in the ultrafiltrates showed a different pattern. It is clear from Fig. 2, 2 that during the first two months after the operation the copper concentration in ultrafiltrates of the blood rose sharply to 136 μg%(m±29; $P < 0.02$). In the later stages a gradual decrease was observed in this copper fraction, and in the terminal period of the animals' life it was only half the preoperative value. The increase in the copper concentration in the blood ultrafiltrate in the first months after the operation was possibly the result of the active release of this element from the depot organs or of redistribution of copper between the organs and tissues, coupled with a disturbance of the ability of the tissues to concentrate copper and to retain it in the form of complexes with biopolymers. This is confirmed by the figures for the copper concentration in certain organs and tissues of these animals given in the table. By comparison with the controls, the copper concentration in the spongiosa of the hemopoietic part of the epiphyses, in the other bones, in the liver, the pancreas, the kidneys, and the muscles showed a sharp decrease.

Removal of the pyloro-duodenal portion of the stomach led to less clearly defined changes in the early periods after the operation and gastrectomy. The copper concentration in the whole blood was practically unchanged on the 10th-30th days, while the concentration in the ultrafiltrate at this period was smaller. Starting from the second month and continuing for 5-6 months, a parallel increase in the copper concentration in the whole blood and ultrafiltrates of the blood was observed in the animals of this series. In the terminal period of the

Copper Concentration in Organs and Tissues of Dogs after Resection of Various Parts of the Stomach (in mg/100 g fresh substance, M±m)

Operation	Tissue							
	liver	kidney	pancreas	spleen	muscle	bone (spongiosa)	bone (other)
Laparotomy (6 dogs)	2,2±0,23	0,54±0,054	0,26±0,017	0,12±0,008	0,14±0,017	3,5±0,7	2,3±0,25
Gastrectomy (7 dogs)	1,5±0,14	0,36±0,014	0,15±0,001	0,10±0,005	0,09±0,013	1,7±0,09	0,8±0,04
	$P<0,05$	$P<0,05$	$P<0,001$	$P>0,05$	$P<0,05$	$P<0,001$	$P<0,001$
Resection of the pyloro-duodenal part of the stomach (7 dogs)	0,6±0,08	0,34±0,014	0,12±0,004	0,12±0,008	0,03±0,006	0,7±0,06	0,5±0,05
	$P<0,001$	$P<0,05$	$P<0,001$	$P>0,5$	$P<0,001$	$P<0,001$	$P<0,001$
Segmental resection of the body of the stomach (7 dogs)	2,3±0,2	0,47±0,036	0,20±0,008	0,26±0,006	0,13<0,005	3,5±0,4	1,9±0,3
	$P>0,5$	$P>0,2$	$P<0,01$	$P<0,001$	$P>0,5$	$P>0,5$	$P>0,2$

animals' life, the copper concentration in the blood ultrafiltrate fell almost to its initial level. The copper concentration in the spongiosa of the bony epiphyses, the other parts of the bones, the liver, pancreas, and kidneys, fell considerably.

A different pattern was observed in the dogs after segmental resection of the body of the stomach. For 8-9 months after the operation the level of copper in the whole blood and blood ultrafiltrates showed no significant change. After 9-10 months and throughout the second year of the observations, the copper concentration in the whole blood and ultrafiltrates increased appreciably. The copper concentration in the organs and tissues of the animals of this series sacrificed after two years of observation corresponded to its level in the organs of the control group of animals.

The most marked changes in copper metabolism in the dogs, leading to the development of hypochromic anemia and to wasting and death of the animals in the late stages after the operation, were thus observed after gastrectomy and resection of the pyloroduodenal portion of the stomach.

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