ABSORPTION OF IONIZED AND COMPLEX-BOUND COPPER IN THE STOMACH AND SMALL INTESTINE

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Copper is absorbed most intensively in the jejunum. Of the copper compounds investigated (copper sulfate, sodium ditartrocuprate, and copper glycocholate), the last mentioned was absorbed fastest.

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The extensive use of copper compounds in medical practice makes a detailed study of the ways by which copper is absorbed in the gastro-intestinal tract essential. Data in the literature on this problem are scanty and at times conflicting. The view that copper compounds are hardly absorbed at all in the gastro-intestinal tract and are excreted only with the feces has been rejected. The constant presence of copper in the urine demonstrates that absorption of copper compounds occurs in the digestive apparatus. Crampton and Matthews [10], in experiments in vitro using bags prepared from segments of the mucous membrane of the hamster intestine observed the most intensive absorption of copper by the mucous membrane of the distal portion of the small intestine. S. Ya. Kaplanskii [4] found that copper entering the human and animal body with the food is absorbed in the proximal portion of the small intestine; under normal conditions on the average 20-30% of the copper entering the body is absorbed in the human intestine, but different copper compounds are absorbed to a different extent. Many authors have reported that copper salts are absorbed better in the proximal portion of the small intestine [2, 3, 5, 7, 11].

The object of the present investigation was to study the effect of the form of the chemical bond of copper in complexes on the degree of its absorption in the digestive tract.

EXPERIMENTAL METHOD

Altogether 108 chronic experiments were performed on dogs with a Heidenhain gastric pouch and with isolated loops of the jejunum and ileum formed by Thiry's method. Copper compounds (copper sulfate, sodium ditartrocuprate, copper glycocholate) were administered to the animals as solutions into the gastric pouches or intestinal loops at the rate of 500 μg copper/kg body weight. Absorption of the copper compounds was judged from changes in the amount of copper removed from the gastric pouch and isolated intestinal segments 30 min, and 1 and 2 h after injection of the test salts. The copper content in the fluid obtained from the gastric pouch and intestinal segments was determined quantitatively by a spectrographic method.

EXPERIMENTAL RESULTS

Under normal conditions copper was absorbed in the gastric pouch at the following rate: copper sulfate 26.3% after 30 min, 38% after 1 h, and 50.2% after 2 h; copper glycocholate (after the same periods) 38.6, 50, and 61% respectively; copper in the composition of sodium ditartrocuprate 20, 29.2 and 38.8% respectively (Fig. 1, A).

Copper sulfate was absorbed in the jejunum to the extent of 40% after 30 min, 62% after 1 h, and 70% after 2 h; after the same periods absorption of copper glycocholate was 52, 76, and 84%, and of sodium ditartrocuprate 23, 43.2, and 52%, respectively (Fig. 1, B).

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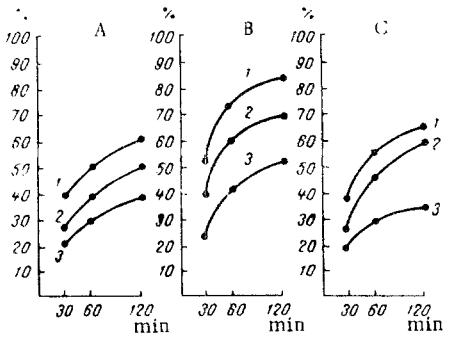

Fig. 1. Absorption of copper in stomach (A), jenunum (B), and ileum (C), in percent of quantity of copper administered. 1) Copper glycocholate; 2) copper sulfate; 3) sodium ditartrocuprate.

In the ileum, absorption of copper sulfate was 26.5% after 30 min, 47% after 1 h, and 59.3% after 2 h; absorption of glycocholate was 37.8, 56.1, and 66.4, and of ditartrocuprate 19.3, 28.8, and 35%, respectively (Fig. 1, C).

With an increase in duration of the experiment, absorption of copper compounds in the gastric pouch and small intestine thus increased. The copper compounds studied were absorbed most intensively in the jejunum. Copper as glycocholate was absorbed better than in the form of sulfate and ditartrocuprate in the stomach and segments of the small intestine.

According to data in the literature [3, 4] the copper salts of amino acids, compounds of copper with casein, and copper of hemocyanin are assimilated comparatively easily by living organisms, while copper in the composition of hematoporphyrin is almost completely unassimilated. Absorption of copper is sharply inhibited by egg yolk if given at the same time as the copper salts.

The copper atom in copper sulfate is bound by an electrovalent bond, and on dissociation of the salt a copper cation is formed. In the complex compound sodium ditartrocuprate – $Na_4[Cu(C_4H_3O_6)_2]$, the copper atom is a central coordinating ion whose d-orbits participate in the formation of the bond with ligands [9]. During dissociation of such a complex the copper is a component of the complex anion. So fas as copper glycocholate is concerned, in this case the metal forms a complex compound of chelated type, during the formation of which the copper, on the one hand, replaces a porton in the carboxyl group of glycocoll and, on the other hand, it presents vacant orbits for the p-electrons of nitrogen atoms [8]. Donor acceptor interaction leads to practically complete loss of dissociation of the intracomplex compounds [6]. All natural complexes of metaloprotein type, it will be noted, are built in accordance with this last principle [1].

The experimental results showed that assimilation of copper by the body is directly dependent on the type of chemical bond holding the copper in the compounds and it decreases with the change from copper glycocholate to copper sulfate, and from that to sodium ditartrocuprate.

Participation of d-orbits in the formation of bonds of the central copper atom results in poor assimilation of sodium ditartrocuprate. The highest level of assimilation possessed by the intracomplex copper of copper glycocholate is due in all probability to the fact that the body does not break this complex down to ionized copper, but incorporates it into cuproprotein complexes in the form of a ready-made chelated fragment.

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