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Absorption of Selenite and Selenomethionine from Ligated Digestive Tract Segments in Rats[1] (39531)

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Limited information is available on the absorption of selenium from the digestive tract of animals. By use of a nonabsorbable marker and radioactive selenium, this element was shown to be secreted into the first one-fifth and absorbed from the remainder of the small intestine in sheep and swine (1). Absorption of this element did not occur from the rumen of sheep or from the stomach of swine. *In vitro* work with everted intestinal sacs from the golden hamster revealed that selenomethionine was actively transported, but selenite and selenocytstine were not (2). Since ouabin inhibited the transport of selenomethionine, the authors suggested that the sodium pump may play a role in the transport of this amino acid (3). The transport of selenomethionine was inhibited by the corresponding sulfur analog, L-methionine, but transport of selenite and selenocystine was not inhibited by sulfite and cystine, respectively.

The ligated segment technique has been used to study the absorption of copper, zinc, molybdenum, and iron from various parts of the digestive tract of rats (4). Copper was found to be absorbed most readily from the stomach whereas zinc and iron were taken up most rapidly from the duodenum. In contrast, molybdenum appeared to be absorbed at about equal rates from the duodenum, midsection, or ileum. Since this technique offers the advantage of studying the absorption from various parts of the digestive tract in the intact animal, it was used in the present study to investigate the absorption of selenium. Two chemical forms of selenium, selenite and selenomethionine, were tested to compare their absorption patterns.

Materials and methods. Mature OSU brown rats, about 1 year old, from our breeding colony were used in these studies. Most of the female rats had produced three litters of young, and the males had been used for breeding purposes. The rats had been fed solely Purina rat chow since weaning. This chow contained about 0.3 ppm of selenium.

The absorption of selenium from the ligated segments of rats was studied essentially by the technique reported by Van Campen and Mitchell (4). After an overnight fast, the rats were anesthetized with ether and the peritoneal cavity was opened by a 3.0- to 4.0-cm midline incision. Except for the stomach, the segments to be studied were displaced, still intact, from the abdominal cavity and ligated anteriorly and posteriorly. The latter ligature was left loose, the needle was inserted through the intestinal wall, the ligature was tightened around the needle, and radioactive selenite or selenomethionine was injected into the lumen. The segments studied were the stomach, the duodenum (about 0.5 to 7.5 cm distal to the pyloris), the jejunum (about 32 to 40 cm proximal to the ileocecal juncture), and the ileum (about 2 to 8 cm proximal to the ileocecal junction). The stomach was ligated only at the pylorus, leaving the esophagus open. After the injection had been made, the segment was returned to the body cavity and the incision closed with sutures and stainless-steel wound clips before returning the rats to their cages. After 3 hr, the rats were killed by anesthesia with ether, blood was taken by heart puncture with needle and syringe, and tissues (heart, liver, and kidney) were taken for selenium-75 count-

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ing in a Packard Tri-Carb, Model 3002, gamma counter.

The heart and kidney were placed in saline, blotted with tissue paper, and placed in counting tubes. The liver was also placed in saline, blotted with tissue paper, and weighed. A sample was placed in a tared counting tube. The data are expressed as percentage of the administered activity recovered in each tissue. Values for blood were calculated by multiplying the counts per minute per gram of blood by 0.07 times the body weight of the animals, and values for kidneys were obtained by doubling the counts obtained from one kidney. The data were subjected to an analysis of variance for statistical evaluation.

About 5 μCi (0.5 μCi of ^{75}Se/μg of selenite) as sodium selenite in 0.3 ml of saline or 5 μCi (10 μCi of ^{75}Se/μg of selenomethionine) as L-selenomethionine in 0.3 ml of saline were injected into each ligated segment. These isotopes were obtained from Amersham/Searle Corporation, Arlington Heights, Ill. The purity of these compounds was not determined.

Results. Essentially no selenium as sodium selenite was absorbed from the stomach (fig. 1). However, extensive absorption occurred from the other segments. Slightly greater amounts of selenium were found in liver when the selenium was placed in the duodenum than when placed in the jejunum or ileum. The liver contained significantly ($P < 0.01$) more selenium than the blood. Of the tissues examined, the heart contained the smallest amount, followed by the blood, with the liver containing the greatest amount of the isotope. The combined data from the duodenum, jejunum, and ileum revealed that the liver contained about 10 times more radioactivity per gram than the blood on a per milliliter basis.

As was the case with selenite, there was very little absorption of selenomethionine from the stomach and extensive absorption from the other segments (Fig. 2). The whole liver, however, contained amounts of selenium similar to that found in the blood, in contrast to that observed for selenite. The combined data from the duodenum, jejunum, and ileum revealed that the liver contained about 3.5 times more radioactivity on a per gram basis than the blood on a per milliliter basis. On the basis of percentage of dose in each tissue, the heart contained the least amount, followed by the kidneys, but the blood and liver contained about an equal percentage of the isotopic dose.

On the basis of the summed recovery from liver, blood, kidneys, and heart there was

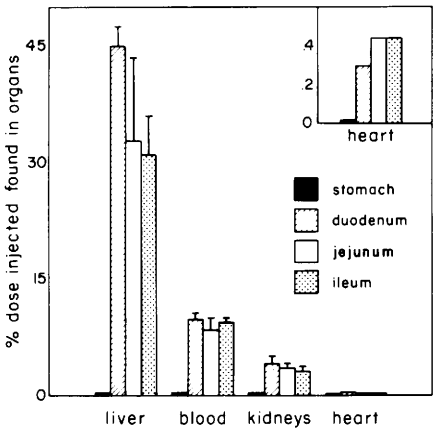

FIG. 1. Absorption of [^{75}Se]selenite from ligated intestinal segments in rats. The values represent the means + standard deviation of five rats (three males and two females) for each intestinal segment. The average weight of the males was 468 g and the average weight of the females rats was 286 g. The males and females showed similar patterns of absorption.

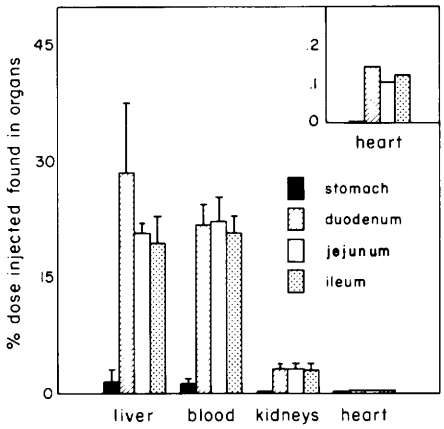

FIG. 2. Absorption of [^{75}Se]selenomethionine from ligated intestinal segments in rats. The values represent the means + standard deviation of five rats (two males and three females) for each intestinal segment. The average weight of the males was 420 g and the average weight of the female rats was 261 g. The males and females showed similar absorption patterns.

no difference between the absorption of selenite and selenomethionine from the four digestive tract segments (Fig. 3). Figure 3 graphically illustrates the minimal absorption of both selenium-containing compounds from the stomach, and absorption is significantly less ($p < 0.001$) than from the other three segments. The greatest absorption for both selenium-containing compounds appears to be from the duodenum, with nonsignificantly less absorption from the jejunum or ileum.

Discussion. Whether selenium was in the form of selenite or selenomethionine, essentially no absorption occurred from the stomach. Our data are in agreement with those for sheep and swine, which indicate no absorption of selenium from the preintestinal tract (1). The significance of these observations is that the various elements are not absorbed from the same intestinal segment. Essentially no absorption occurred from the stomach, which is in marked contrast to that reported for copper (4). Copper was reported to be absorbed to the greatest extent from the stomach. Interestingly, the chemical form of selenium used in the present study had no significant influence on its absorption from the intestinal segments, but the ratio (10.4:1) of the concentration of selenium from selenite in liver on a per gram basis to that in the blood on a per milliliter basis was much greater than this ratio (3.5:1) for selenomethionine.

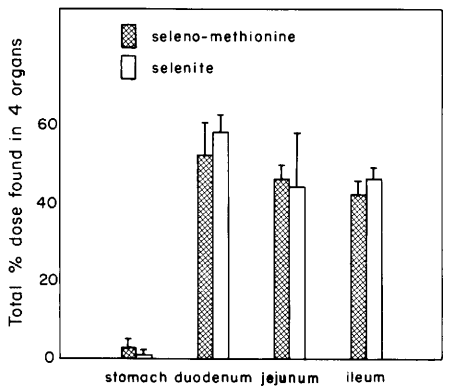

FIG. 3. Total absorption of [^{75}Se]selenite or [^{75}Se]selenomethionine from ligated intestinal segments. The data are the accumulated values presented in Figs. 1 and 2.

In vitro work with everted intestines from the golden hamster indicated that selenomethionine was actively transported across the intestinal tract, but selenocystine and selenite were not (2, 3). No explanation was offered by these workers for the difference in absorption of these selenium-containing compounds. It cannot be determined from the present data whether selenite and selenomethionine were actively transported. Since both compounds showed similar absorption patterns from the various intestinal tract segments, it might be suspected that these two selenium compounds were absorbed by similar mechanisms.

The ligated intestinal segment technique has been used to study the effects of zinc, cadmium, silver, and mercury on copper absorption (5), to study the interference of copper with zinc absorption (6), and to study the influence of amino acids on iron absorption (7). Thus, this technique would appear to be useful for studying various factors influencing selenium absorption, particularly the effects of sulfur analogs on absorption of this element. The *in vitro* inhibition of selenomethionine absorption by methionine in the everted intestinal sacs of the golden hamster (3) indicates that such studies should yield useful information.

Summary. The absorption of selenium as sodium selenite or as selenomethionine was studied with ligated intestinal segments in rats. Essentially no absorption of either compound occurred from the stomach, whereas the greatest absorption occurred from the duodenum, with slightly smaller amounts from the jejunum or ileum.

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