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Comparison of Concentration of Glucose in the Stomach and Intestine after Intragastric Administration.

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(Introduced by S. S. Goldschmidt.)

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The absorption of glucose from the intestinal tract has long interested investigators of carbohydrate metabolism. The investigations have been, in the main, performed by one of 2 methods. In the one, isolated segments of the small intestine have been used as an acute experiment in anesthetized animals, or as Thiry or modified Thiry loops in unanesthetized animals. In the other, either the whole or a large part of the gastro-intestinal tract has been used in anesthetized or unanesthetized animals. Data obtained have been published under the general heading of intestinal absorption, and certain generalizations have been drawn by one group which were often not substantiated by another. Comparisons of data were frequently made when the experimental methods were entirely different. Even when similar methods were used the data of different investigators often did not agree.

The effect of anesthesia, of different segments of the small intestine, the condition of the animal, and probably more than these the effect of the stomach on any solution of sugar placed in it, have frequently not been taken into consideration in evaluating the data obtained by the different groups of investigators.

Data which we had obtained from isolated jejunal loops, prepared by the method of Johnston[1] did not substantiate Cori's[2] generalizations, that regardless of concentration glucose solutions were absorbed at the same rate. Nor did we find a straight line relationship between time and the amount of glucose absorbed, or any correlation between body weight and the glucose absorbed from the jejunal segment. We were, therefore, led to conclude that, at least, as far as the isolated jejunal loop of the unanesthetized dog, Cori's generalizations were not correct.

We were aware, however, that while we were using only a single segment of a physiological unit, Cori had used the unit as a whole. Whether this difference in the experimental method might, at least in

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[1] Johnston, C. G., PROC. SOC. EXP. BIOL. AND MED., 1932, **30**, 193.

[2] Cori, C. F., *J. Biol. Chem.*, 1925, **66**, 691.

part, account for the contradictory results remains to be established. Cori[2] noted that significant amounts of fluid were found in the stomach at the conclusion of some of his experiments. Since our experiments were done on the dog we believed it important to ascertain what effect the stomach of this animal may have on any solution of glucose which is introduced into it.

Unanesthetized healthy dogs weighing from 11 to 15 kg. were starved for 24 hours before the experiment. A stomach tube was introduced and a measured amount (200 cc.) of a solution of glucose (Bacto-dextrose, Difco) of varying concentrations, which had been warmed to body temperature, was introduced. When this had entered the stomach a small amount of water (10 to 15 cc.) was used to rinse the flask which contained the glucose and this wash was then placed in the stomach through the tube.

The animals were under constant observation during the period of the experiment which was in each instance, one hour. If any regurgitation or vomiting occurred at any time from the introduction of the glucose solution to the time of completion of the experiment the animal was discarded.

About 2 minutes before the completion of the experiment the animals were rapidly anesthetized by the intravenous injection of 50 mg. of sodium amytal per kilo of body weight. We did not encounter any vomiting during this phase of the experiment nor were the animals ever excited.

The abdomen was rapidly opened and a Spencer-Wells forceps placed on the esophagus just below the diaphragm, 2 at the pylorus, and one on the small bowel at the ileocecal junction. These sections were rapidly removed and the contents collected in separate receptacles. The segments were not washed out since we were interested primarily in the concentrations of the solutions in the 2 segments and not in the absolute amounts of glucose present.

The amount of fluid in each container was measured and the glucose determined by the method of Benedict.[3] No correction was made for the reducing substances normally present in the stomach or small bowel, since in previous experiments we had determined that the amount present in the small intestine was negligible.

Results. The data obtained (Table I) demonstrate in a striking manner the rapidity with which water is drawn into the stomach, thus diluting the sugar solution which the stomach contained. Though 215 cc. was the maximum amount of fluid introduced into

[3] Benedict, S. R., *J. Biol. Chem.*, 1911, **9**, 57.

the stomach more than 500 cc. have been removed at the end of an hour. More striking is the uniformity of the concentrations of glucose recovered from the small bowel.

TABLE I.
Changes in the Concentration of Glucose.†

Dog	Time	Conc. Glucose in	Conc. Glucose out (Stomach)	Conc. Glucose out (Small Intestine)
No.	hr.	mg. %	mg. %	mg. %
762	1	3.5	2.3	—
789	1	6.0	3.7	—
793	1	10.4	6.3	3.5
788	1	14.9	7.4	3.3
792	1	19.9	10.5	3.6
766	1	20.0	5.0	2.6
808	1	20.2	5.9	2.9
790	1	23.6	9.8	2.4
794	1	27.0	10.8	3.6
809	1	50.0	17.9	5.3

† 200 cc. of solution were used in each experiment.

The concentrations recovered from this portion of the intestine are of such an order that even had equal amounts of these concentrations been placed in an intestinal loop, no differences in the rate of absorption may have been demonstrable. Since, however, the segments removed were not washed and since the precautions necessary, had total amounts of glucose been our objective, were not taken, we will include no data on the rate of absorption of glucose in this paper.

There can be little doubt from the data presented that where the gastro-intestinal tract is used as a physiological unit for studying the absorption of glucose it is not possible to draw any inferences on the rate of absorption from the small intestine, had only this portion of the gut been exposed to solutions of widely varying concentrations.

The changes in concentration of the glucose solution which remains in the stomach due to the rapid mobilization of water, tend to bring the concentrations into a closer relationship within a period of only one hour. A longer period of time would probably result in an even closer equalization. Furthermore, as the stomach contents escape through the pylorus into the duodenum the mechanism tending to equalize the concentrations must continue to be active, since in one animal we have observed the following changes in concentrations one hour after the introduction of a 23.6% solution—stomach 9.8%, duodenum 3.8%, jejunum and ileum 2.4%.

It is not possible at this time to state that the mechanism of dilu-

tion is the sole factor explaining the differences in the results which are obtained when the entire gastro-intestinal tract, or only a segment of this is used. The rapidity of emptying of the stomach and the motility of the small intestine may also be factors. When a jejunal segment is used no relationship exists between body weight and the rate of absorption of glucose while Cori[2] and Trimble, Carey and Maddock[4] have found that such a relationship exists when the gastro-intestinal tract is used as a physiological unit. This relationship must depend upon the rate of passage of the glucose solution into the small bowel or to differences in the rate of absorption from that portion of the intestine which acts as the absorbing membrane.

Conclusions. Data have been presented which demonstrate the rapidity with which solutions of glucose of varying concentrations when placed in the stomach of the dog are changed, so that when the solutions reach the small intestine the variations in the concentrations are of a small order. These findings may in part explain the differences in the rate of absorption when the gastro-intestinal tract is used as a physiological unit and when only a single segment of this unit is utilized.

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Bloodless Method for Recording Respiration and Quantitative Determination of Alterations of Sensation in Small Animals.

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Schmitz and Loevenhart[1] published a method for judging the onset and duration of anesthesia in the sciatic nerve of rabbits by the disappearance of changes in respiration when the distal portion of the nerve was stimulated. They recorded the respiration with a tambour attached to a cannula introduced into the trachea.

In order to study anesthesia (general, local and spinal) analgesia and hyperalgesia in small laboratory animals, without performing surgical operations, we have devised the apparatus shown in Fig. 1.

[4] Trimble, H. C., Carey, B. W., and Maddock, S. J., *J. Biol. Chem.*, 1933, **100**, 125.

[1] Schmitz, H. L., and Loevenhart, A. S., *J. Pharmacol. and Exp. Therap.*, 1924, **24**, 159, 167.