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Ileal Glucose Absorption After Jejunectomy in the Rat[1]

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Abstract. Eleven male rats were subjected to jejunectomy under ether anesthesia with end-to-end intestinal anastomosis. After recovery they were allowed to eat *ad libitum* and growth was little impaired. An *in vivo* test of absorptive capacity for glucose was applied to the surviving ileum of the jejunectomized animals and to the corresponding segment of ileum in eleven untreated rats. The correlation coefficient for the body weight and the amount of glucose absorbed from a Krebs-Ringer-bicarbonate solution containing 16 to 17 μmol/ml (300 mg. percent) glucose in all animals was 0.45. Accordingly, absorption of glucose and of fluid volume was expressed as amounts absorbed/100 gm. body weight/one-hour test. Fluid volume absorbed followed the amount of glucose absorbed; the correlation coefficient between these parameters was 0.94. The ileal absorptive capacity for glucose significantly increased in five rats tested about 74 days post-jejunectomy compared to that in the 11 control animals. Six rats tested about 147 days post-operatively showed significantly less absorptive capacity than the shorter term group, and less, though not significantly, than the control group. Possible factors underlying these results are discussed.

Glucose absorption by *in vivo* or *in vitro* segments of the small intestine in the rat is characterized by a gradient longitudinally which shows diminishing absorptive capacity as progress is made from the duodenum to the terminal ileum.[1, 2] These observations cannot be explained on the basis of surface area available for absorption.[3] Furthermore, it has been demonstrated that other substances may exhibit quite different patterns of longitudinal distribution of absorptive capacity by isolated segments. For example, bile salts are absorbed four times faster by the terminal ileum than by proximal duodenum with a smooth gradation in between.[4]

Numerous cases of survival and complete absorption of carbohydrate in experimental animals and in man after resection of relatively large portions of the small intestine have been reported. While these studies suggest that there exists a large reserve in the over-all capacity of the small intestine for carbohydrate absorption, they do not provide evidence for a possible adaptive increase in absorptive capacity of surviving small intestine. For example, massive resection of the distal small intestine in rats resulted in failure to absorb about 25 percent of ingested carbohydrate in contrast to about 9 percent loss after massive proximal small intestine resection.[5] These results are opposite to what might have been predicted from absorptive capacity

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measurements in isolated segments. Since the absorption test applied was of the dietary balance type, greater propulsive motility of the jejunum could have accounted for the difference seen. The absorption sites in the jejunum could have been passed too quickly, whereas, more time may have been provided for absorption in the less motile ileum. The object of the present study was to test whether or not there was any change in the absorptive capacity of the ileum over a period of time after removal of the jejunum.

Methods

The small intestine from the ligament of Treitz to a point about 40 cm. proximal to the ileo-cecal junction was removed in male, albino rats (Holtzman). The operation was performed under ether anesthesia and was completed by an end-to-end anastomosis of the remaining small bowel. The tests of absorptive capacity of the surviving ileum in the experimental groups and in the corresponding part of the small intestine of unoperated control animals were also conducted under ether anesthesia. Thus, for the absorption tests a midline abdominal incision was made and ileocecal junction identified. In the control group a point along the small intestine 40 cm. proximal to the ileocecal junction was encircled by a loose ligature. In the rats which had been treated by the resection procedure the site of the anastomosis was located and an encircling ligature placed one cm. distal to that point. A glass cannula connected to a 50 ml. syringe by means of a three-way stopcock was inserted into the lumen of the small intestine at the proximal end of the segment to be tested. The terminal ileum was incised about one cm. proximal to the ileocecal junction. Before tying a cannula into this opening, the segment was gently flushed with Krebs-Ringer-bicaronate solution containing 16 to 17 μmol/ml (300 mg. percent) glucose until the fluid emerged clear. A final air flush was used to empty the segment in a gentle but standardized and easily duplicated fashion. A cannula was then inserted into the terminal ileal incision and connected through a three-way stopcock to a 10 ml. syringe barrel from which the plunger had been removed so that the barrel could serve as a graduated reservoir for maintaining the hydrostatic pressure within narrow limits in the segment during the absorption test. Ten minutes was allowed to elapse between these preparations and the start of the absorption test. The solution for the absorption test was the same as that used for the rinsing step. It was introduced from the 50 ml. syringe, which was then closed off from the lumen of the intestine except when additions were needed to keep the level in the terminal reservoir from falling more than 12 mm. At the end of 60 minutes the solution remaining in the entire system was drained out through the distal three-way stopcock and the intestinal segment flushed with air as at the end of the preliminary rinsing procedure. Only one test of absorption was done in each animal. Absorption of glucose was estimated as the difference between the amount of glucose initially present in the system and the amount recovered as measured by the Saifer and Gerstenfeld modification of the Glucostat Method.[6] The volume of fluid absorbed was also determined by difference between input and output volume measurements.

Results

Although an attempt was made to have all the rats tested at nearly the same body weight, the weights at the time of the absorption test ranged from 330 to 490 gm. For all animals tested the correlation coefficient between body weight and absorption of glucose was found to be 0.45. To reduce scatter from this source all absorptions have been expressed in terms of absorption per 100 gm. body weight per one-hour test. Comparisons between groups have been done by group comparison analysis.[7] The data obtained in 11 control animals, in five animals tested at about 74 (73-75) days following resection of the intestine, and in six animals tested at about 147 (143-150) days after the operation are summarized in Table 1. Results of the statistical comparisons

Table 1

Body Weight and Absorption Data

Group	No.	*Weight at Operation gm	*Weight at Test gm	*Absorbed/100gm/hr Glucose μmol	*Absorbed/100gm/hr Fluid ml
Control	11	—	440 ±49	58.2 ±19.7	2.23 ±0.58
Test 1 (74 days)	5	296 ±25	368 ±24	86.5 ±21.7	3.02 ±0.61
Test 2 (147 days)	6	224 ±10	373 ±33	46.4 ±18.4	1.93 ±0.61

*Means ± sample standard deviations.

Table 2

Summary of Statistical Comparisons of Sample Means

Glucose Absorption	(μmol/100gm/hr)	t-ratio
Control vs. T-1	58.2 vs. 86.5	*2.62
T-1 vs. T-2	86.5 vs. 46.4	**3.49
Control vs. T-2	58.2 vs. 46.4	1.23
Fluid Absorption	(ml/100gm/hr)	
Control vs. T-1	2.23 vs. 3.02	0.56
T-1 vs. T-2	3.02 vs. 1.93	*3.01
Control vs. T-2	2.23 vs. 1.93	1.00

*Significant at 5 percent level of probability.
**Significant at 1 percent level of probability.

are shown in Table 2. The increase in the mean value for absorption of glucose in Group 1 (74 days) over that for controls was statistically significant at the 5 percent level of probability. Group 2 (147 days) had a mean value for glucose absorption that was significantly less, at the 1 percent level of probability, than that for Group 1. Thus, the support for an increase in absorptive capacity that appeared to have started with the 74-day group was not borne out by the results in the 147-day group. The latter group's mean value was less, but not significantly, than the control group mean. A high correlation coefficient of 0.94 was obtained between volume of fluid and glucose absorbed. The same qualitative pattern of differences was found for these values as for the glucose absorption figures. For fluid absorption only the difference between the means of the two test groups was statistically significant at the 5 percent level of probability. The weight of the rats at the time of the resection operation is shown in Table 1. The rats in the second group were obviously smaller, i.e., younger, when the surgery was performed. This was deliberately arranged in order to have all animals about the same size for the absorption test.

Discussion

It is evident that growth at about the rate of a gram a day was achieved by both treated groups after recovery from the resection operation. This is close to expected growth rates in normal animals on an *ad libitum* diet.[8] Since the growth rate did not diminish markedly in either treated group, it may be concluded that the growth of these rats was maintained after jejunectomy without calling for absorption rates at or near capacity.

Evidence suggesting an increase in absorptive capacity of the ileum following removal of the jejunum was obtained in the first part of this study. An apparent recession in the absorptive capacity to control levels was seen in the longer post-jejunectomy group. Fasting has been associated with reduction in absorption of glucose[9] and semi-starvation has been associated with no change[10] or an increase[11] in glucose absorption from the entire small intestine tested by *in vivo* isolated loop methods comparable to the technique used in this study. Except for a few days post-operatively, starvation or semi-starvation did not appear to be a factor in the present study. The age at the time of intestinal resection and/or dietary deficiencies developing with time, despite weight gain and general appearance of good health, may have been factors involved in the marked functional difference between the two test groups.

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