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Influence of Obstruction of the Bowel upon its Length and Weight.†

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No definite information is available as to the effect of obstruction upon the length and weight of the bowel. Because of expressed differences of opinion among clinicians relative to this matter, it was felt worth while to determine the influence of obstruction on bowel length and weight.

In 12 dogs segments of bowel one foot in length were marked off by placing silk ligatures on the mesenteric border of the bowel from the duodenum to the site of obstruction, the terminal ileum. The abdomen was then closed. After a period of time (Table I) the dogs were operated upon again and the length of each segment of bowel was remeasured.

The entire small intestines of 10 weighed normal dogs used in experimental demonstrations for physiology classes were obtained

* C represents a complete, P a preliminary manuscript.

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TABLE I.
Shortening of the Bowel in Simple Ileal Obstruction.

Dog	Days Obst.	Final Length of 12-inch Segments from Site of Obstruction, Ileum to Jejunum.								
1	4	8.75	9.00	7.50	9.00	9.50				
2	4	12.00	12.00	8.50	9.50	9.50	9.50			
3	4	9.50	9.00	8.00	7.00					
4	4	8.25	7.00	7.25	7.25	7.75				
5	4	7.25	6.75	7.00	7.00	8.25	8.50	8.25		
6	4	9.25	8.75	8.50	13.50	6.75	7.25			
7	2	9.50	10.00	10.00	11.50	10.50	12.00	11.00	9.00	
8	2	8.75	8.25	7.75	8.75	7.75	8.50	9.25	11.0	10.0
9	1	10.50	10.50	(Only two lower segments marked off)						
10	1	8.50	5.50	"	"	"	"	"	"	"
11	3	10.00	8.00	"	"	"	"	"	"	"
12	3	8.50	9.75	"	"	"	"	"	"	"

immediately after death. The bowel was cut up into foot segments, the mesentery and fat were carefully dissected from the bowel wall, and the mucosa was cleaned by wiping with gauze. The segments were weighed to 0.1 gm., and segments of both jejunum and terminal ileum were desiccated in a drying oven at 100°C. for 4 days for a determination of the percentage of water content.

A similar procedure was carried out with the small bowel of 10 dogs with simple ileal obstruction of from 4 to 8 days' duration. In another group of 10 dogs, the bowel segments were marked off by tying a silk ligature on the mesentery at foot intervals from the duodenum to the site of obstruction, the terminal ileum. This was done at the time of operation immediately upon establishing the obstruction.

To determine more accurately the degree of circulatory stasis which occurs in obstruction and its effect on the weight of the bowel, the following experiment was carried out:

In 10 dogs under nembutal intravenous anesthesia a small segment of normal ileum was resected. Both proximal and distal ends were inverted with purse string sutures leaving a simple ileal obstruction and the abdomen was closed. At stated intervals they were operated upon again and another segment, the terminal portion of the obstructed bowel, was removed. The segments were cut free of mesenteric fat, cleaned by wiping with gauze, and reduced to a fine meaty pulp with scissors. Exactly 10 gm. of each specimen was extracted and its myo-hemoglobin determined by the method of Whipple, *i. e.*, by exposure to 0.15 N ammonium hydroxide (50 cc.) at ice box temperatures for 20 hours. The mixtures were then filtered through double layers of cheesecloth and the filtrates refiltered through fine filter paper. The resulting solutions of myo-hemoglobin were satu-

rated with carbon monoxide (illuminating gas) for 5 minutes. The solution of carbon monoxyl hemoglobin obtained from the normal bowel was compared colorimetrically with the solution prepared in exactly the same manner from the specimen obtained after a period of obstruction. The average of 5 readings was taken and values obtained as given in Table VI.

Results. In every case there was noted a definite shortening of the bowel, the length of a segment which before obstruction measured 12 inches decreasing by as much as one-third after obstruction. In only one instance was a segment of obstructed bowel longer than before obstruction. (Table I.)

According to several workers, the first response of the bowel of the guinea pig to distension is a contraction of the longitudinal muscle layers.¹ The shortening may be as much as 20 to 25% of its entire length. Van der Reis and Schembra² present observations to show that the functional length of the small bowel in man is only 2.2 to 2.7 meters or 6 to 15 feet in length. They contend that in the living person the bowel is much shorter than in the cadaver, when it usually measures about 22 feet.

It is here likewise shown that distension of the bowel accompanying mechanical obstruction in the dog also causes shortening. Hypertonicity of the obstructed bowel with marked contraction of the longitudinal muscular layer is probably largely responsible for this shortening.

The increase in weight of the ileum immediately above the site of obstruction was determined to be 114% when compared to the normal weight (Table III). When the factor of shortening of the bowel was eliminated, the true gain in weight was found to be 34% (Table IV). Water content comparison of normal and obstructed bowel showed an average increase of about 7% in the ileum above the site of obstruction and 4.7% in the jejunum remote from the obstruction (Table V). There is no dehydration of the bowel wall even though the systemic tissues are desiccated and the blood concentrated.

The weight per foot of the normal small intestine usually decreases from the duodenum to the terminal ileum. There seems to be a downward gradient, even in weight (Table II).

In simple ileal obstruction there is a reversal of the normal weight gradient, *i. e.*, the ileum above the site of obstruction weighs the

¹ Trendelenberg, P., *Arch. f. exp. Pharm. u. Path.*, 1916, **81**, 55; Crane, J. W., and Henderson, V. E., *Am. J. Physiol.*, 1924, **70**, 22.

² Van der Reis and Schembra, F. W., *Z. f. d. ges. Exp. Med.*, 1926, **52**, 74.

TABLE II.
Weight of Consecutive Feet of Normal Intestine from Ligament of Treitz to Terminal Ileum.

Dog	Weight kg.	Wt. of Consecutive 1-ft. Segments of Bowel, Jejunum to Ileum, in gm.
1	16	47-40-40-45-43-43-39
2	21	36-38-40-40-37-29-26
3	40	46-44-42-42-47-44-40-36
4	22	39-35-32-32-30-25-26-24-20-25-24
5	25	42-40-40-39-36-38-35-35-34
6	8	37-33-30-32-26-18
7	14	34-33-32-32-30-26-22-20-23-21
8	17	34-27-27-28-30-28
9	18	45-39-37-33-29-30-29
10	22	40-34-27-32-33-30-29
Aver. wt.	20	Aver. wt. of one foot of terminal ileum, 28.7 gm.

TABLE III.
Weight of Consecutive Feet of Obstructed Intestine from Ligament of Treitz to Site of Obstruction in Terminal Ileum.

Dog	Weight kg.	Days Obst.	Wt. of Consecutive 1-ft. Segments of Bowel, Jej. to Ileum, in gm.
1	18	7	42-45-51-52-62-70-60-85
2	19	8	41-34-36-36-42-40-41-41-49-68
3	19	6	52-45-40-54-50-43-62
4	19	5	46-44-36-50-55
5	23	6	39-43-48-42-48-62
6	17	4	43-52-50-39-46-55
7	16	6	42-46-46-54
8	18	6	39-39-43-56
9	12	7	30-34-49-52-48
10	15	5	56-56-58-72
11	19	7	29-21-20-19-23-26-30-51
Aver. wt.	17		Aver. wt. of terminal ileum per ft., 60.7 gm. Percent increase114%

TABLE IV.
Weight Changes of Bowel in Simple Ileal Obstruction. Foot Segments Marked off at Time Obstruction Was Made.

Dog	Weight kg.	Days Obst.	Wt. of Consecutive 1-ft. Segments of Bowel, Jej. to Ileum, in gm.
1	14	4	40-32-31-26-29-52-41
2	13	4	21-22-23-30-34
3	14	4	41-45-44-42-57-58
4	18	4	27-25-35-33-37-35
5	8	4	23-16-18-19-35
6	17	4	31-31-35-50
7	10	4	24-20-21-21-27-27-27-39
8	11	2	22-22-20-19-22-23-22-26
9	13	2	25-24-22-25-23-23-24-26-30
10	14	3	21-20-22-22-29-37
Aver. wt.	13		Aver. wt. of terminal ileum per ft.38.5 gm. % increase34%

TABLE V.
Water Content of Normal Bowel as Compared with Obstructed Bowel.

Dog	Normal Bowel		Dog	Obstructed Bowel	
	Jejunum	Ileum		Jejunum	Ileum
1	76.5%	72.6%	1	82.4%	85.1%
2	79.6	78.1	2	84.7	85.0
3	76.3	78.2	3	84.1	80.5
4	77.2	77.2	4	78.0	80.9
5	78.1	77.7	5	77.4	83.3
6	76.2	75.5	6	83.3	85.4
7	75.9	77.8	7	81.2	81.2
8	70.2	72.7	8	81.0	78.4
9	77.4	77.5	9	80.4	83.5
Aver.	76.3%	76.5%	Aver.	81.0%	83.5%
M.D.	±1.7	±1.73	M.D.	±2.39	±2.02

In simple ileal obstruction there is approximately 4.7% increase of water content of jejunum and 7% increase of water content of ileum.

most and there is a decrease in weight in a retrograde manner from the obstructed ileum to the duodenum. This is due to the fact that the segments of bowel immediately above the obstruction increase the most in weight, while those segments of the jejunum farthest away from the site of obstruction increase only slightly in weight (Table III).

The results indicated in Table VI represent relative values of the increase of hemoglobin content of obstructed bowel wall when compared with that of the normal bowel (same dog prior to obstruction). The solutions of myo-hemoglobin obtained from the normal bowel were very dilute, making colorimeter matching difficult. There was a wide range of individual variation, due, no doubt, to a variation in individual response to the conditions of obstruction. It was noted that values of more than 100% increase were the rule. A previous study indicated that this accumulation of blood in the bowel wall in simple obstruction is due to stasis in the vessels and is not interstitial hemorrhage in the gut wall.³

TABLE VI.
Comparative Increase of Hemoglobin of the Bowel Wall in Simple Obstruction.

Dog	Days Obst.	Comparative Increase Over Normal	Dog	Days Obst.	Comparative Increase Over Normal
1	1	5.34 x	6	3	1.20 x
2	1	2.76 ''	7	4	10.65 ''
3	2	3.22 ''	8	4	7.17 ''
4	2	2.80 ''	9	4	2.75 ''
5	3	1.40 ''	10	4	4.54 ''

³ Carlson, H. A., and Wangensteen, O. H., PROC. SOC. EXP. BIOL. AND MED., 1932, 29, 421.

Summary and Conclusions. There is a marked shortening of the bowel in simple ileal obstruction (30 to 50%). The bowel wall above the site of simple ileal obstruction increases over 100% in weight. When the factor of shortening of the bowel is eliminated, the increase of weight is 34%. Edema of the bowel wall accounts for only 7% increase in weight. Next to shortening of the bowel the increase of blood in the bowel wall is most responsible for its great increase in weight.

8037 P

Comparison of Serum and Saline Extracts as Nutritive Media for Mammalian Lymph Node Cultures.

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It has been reported by King (in press) that autogenous serum extracts of bone marrow promoted a more prompt and vigorous migration of lymphocytes, as compared with a saline extract of chick embryo, in cultures of mesenteric lymph node of the adult rabbit. It was also stated that the serum extract was definitely inferior to the saline extract as a coagulant for heparinized plasma.

Stenstrom and King¹ have reported the first study of a series on the effects of radiation of lymph node fragments. The next study is to be a more detailed consideration, the response of lymphocytes to radiation in such cultures. Since the response is prompt and since the characteristic activity of lymphocytes in such preparations is early, attempts were made to determine the medium of choice for promoting a prompt and vigorous lymphocyte migration.

The results of the comparison of the extracts referred to above encouraged further study to determine whether the desirable migration-promoting properties of serum marrow extract might be combined with the desirable coagulant properties of the saline embryo extract. To this end a study was made comparing saline and serum extracts of chick embryo.

In general technique followed was that described by King.² The mesenteric lymph node was removed promptly on stopping the cir-

¹ Stenstrom, Wilhelm, and King, Joseph T., *Proc. Soc. Exp. Biol. and Med.*, 1934, **31**, 909.

² King, Joseph T., *Arch. f. Exp. Zellforsch.*, 1930, **9**, 341.