appear that the intra-intestinal pressures necessary to arrest the blood flow in the wall of the bowel are in excess of pressures observed in the bowel during the course of obstruction. As a matter of fact, Owings, McIntosh, Stone and Weinberg[10] found in simple obstruction of the small intestine in dogs that the sustained intra-intestinal pressure was only 6 to 8 cm. of water (about twice the normal) although under the influences of vigorous peristalsis the pressure at times reached a maximum of 30 to 60 cm. of water.

Further evidence that the circulatory changes usually are not extreme is afforded by the experiments of Morton,[11] who injected the intestinal vessels with India ink and found that although the vessels of the obstructed segment were dilated, the capillary loops had intact walls.

Conclusions. The material presented here leads to the conclusion that in simple obstruction only slight changes (congestion, edema) can be demonstrated and frequently no alteration of microscopic structure is to be observed. Grossly the bowel regularly appears hyperemic but no inflammatory or degenerative changes are observed on histologic study.

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Length of Life Following Various Types of Strangulation Obstruction in Dogs.*

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In a series of 12 dogs, Foster and Hausler[1] reported the survival period following strangulation obstruction to be less than 30 hours. The lengths of intestine strangulated in their series varied between 5 and 26 inches. They tabulated their results and were able to show that the length of life was inversely related to the length of bowel strangulated. In an earlier paper by Murphy and Vincent[2] the sur-

[10] Owings, J. C., McIntosh, C. A., Stone, H. B., and Weinberg, J. A., *Ann. Surg.*, 1928, **17**, 507.

[11] Morton, J. J., *Arch. Surg.*, 1929, **18**, 1119.

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[1] Foster, W. C., and Hausler, R. W., *Arch. Int. Med.*, 1924, **34**, 697.

[2] Murphy, Fred T., and Vincent, Beth., *Boston Med. and Surg. J.*, 1911, **165**, 684.

vival period in a series of 12 cats was reported. These authors varied the type of strangulation which they produced but not the length of gut. Their tabulated results show that the length of life depends upon the type of strangulation produced. Their animals in which the veins were occluded and the arteries left intact died much more rapidly than the animals in which the arteries were completely shut off.

A series of similar experiments were carried out in this department in an attempt to confirm the work of these authors and determine if possible the rôle that the arteries and veins play individually and collectively in the survival period. To evaluate the rôle of each, our experiments were divided into 4 groups.

Methods. In group number I no attempt was made to control the relative degree of arterial and venous occlusion. We hoped by this method to obtain some idea of the variations in length of life which one might encounter when a constricting band was passed about the mesenteric pedicle and bowel wall. Binding tape was used for this purpose. The tape, 1 cm. in width, was passed about the mesenteric vessels and then carried around the bowel wall and tied. The lumen of the bowel as well as its blood supply was thus occluded. It is evident that the degree of occlusion of the arteries and veins in this group depends upon the tightness of the encircling tape. In the succeeding 3 groups, binding tape was used merely to occlude the lumen of the bowel at the ends of the segment strangulated. The mesenteric vessels were occluded by ligating and severing them individually. In group II, all of the arteries and veins to the loop selected were ligated and severed. In group III, all the arteries were ligated, the veins being left intact. In group IV, only the veins were ligated, the arteries being left intact. The operative procedures were carried out under ether morphine anesthesia and aseptic technique was employed in every case. Fifty-six experiments form the basis for this report.

Results. In group I in which an encirclement ligature was placed about the mesentery and bowel in 14 dogs, the survival period varied between 4 to 28 hours. The mean length of life for the group was 16 hours. (Table I.) The length of bowel strangulated in this group varied between 1 and 5 feet. Although the dog with the shortest obstruction lived the longest, we find that the dog with the longest obstruction lived longer than a number of other dogs with shorter obstructions. These apparent exceptions to Foster and Hausler's conclusions were anticipated in view of the fact that the relative degree of arterial and venous obstruction could not be ac-

TABLE I.
Encirclement Ligature.

Exp. No.	Length of Gut in Feet	Length of Life in Hours
46	1	28
45	2½	18
49	3	16
38	3	12½
33	3	4
47	3	7
40	3½	18
41	4	8½
30	4	12
42	4	19
44	4	16½
48	4	15
39	4½	18
43	5	18
		Av. 16 hours

TABLE II.
Ligation of Arteries and Veins.

Exp. No.	Length of Gut in Feet	Length of Life in Hours
46	1	27
70	1	20
72	1	15
90	1	32
64	2	18
67	2	21
81	2	20
83	2	17
84	2	18
89	2	30
45	3	18
71	3	20
82	3	17
49	4	20
65	4	16
79	4	12
48	5	15
69	5	11
		Av. 19 hours

TABLE III.
Ligation of Arteries.

Exp. No.	Length of Gut in Feet	Length of Life in Hours
94	1	18
96	2	24
97	2	19
116	2	20
115	2½	18½
85	3	20
87	3	24
88	3	22
98	4	15
		Av. 20 hours

TABLE IV
Ligation of Veins.

Exp. No.	Length of Gut in Feet	Length of Life in Hours
76	3	4
73	3	9
68	3	8½
62	3	4¼
61	3	11½
52	3½	3½
57	4	4
60	5	6½
59	5	5
58	5	12
56	5	4
55	5	4
53	4½	3½
54	4½	6¼
51	5½	2½
		Av. 5½ hrs.

curately controlled. Further, the weights of the animals varied between 10 and 25 kilos. Therefore, the actual length of gut obstructed gives one no indication of the relative amount obstructed, which is really of greater importance. In group II, in which the arteries and veins were completely ligated in 18 dogs, the shortest survival period was 11 hours and the longest 32. The length of gut strangulated varied as in the preceding group between 1 and 5 feet. The mean length of life for this group was 19 hours. In group III, in which the arteries were tied in 9 dogs, the shortest survival period was 15 hours and the longest 24. The mean length

of life was 20 hours. The length of bowel strangulated varied between 1 and 4 feet. In group IV, in which the veins were tied in 15 cases, the shortest survival period was 2½ hours and the longest 11½ hours. The mean length of life was 5½ hours. The gut length varied between 3 and 5½ feet.

Comment. Analyzing these statistics, one finds that the average length of life in the venous obstruction group is approximately ¼ that of the arterial group, and the combined artery and vein ligature group; it is approximately ⅓ that of group I or the encirclement group in which the degree of arterial occlusion was not absolute in all cases. At autopsy, there was a marked difference in the appearance of the strangulated bowels in the various groups. In group IV, the bowel was always markedly distended; its color was practically always a deep dark mahogany; the serosa was lusterless and not infrequently had a fibrinous exudate on its surface. The serosa was split in a few cases but there was no perforation of the bowel in any dog of this group. On opening the bowel, it was found to contain a large amount of dark bloody fluid of high hemoglobin content. The wall of bowel was always thickened. In some cases, it was as much as 4 times its normal weight. There were frank diffuse hemorrhages throughout the mesentery, being most marked along the course of the mesenteric vessels. The peritoneal cavity of these dogs usually contained from 50 to 250 cc. of a hemorrhagic fluid of rather low hemoglobin content.

The findings at autopsy in the other groups were quite different from these, except for those in group I that died rather early. These dogs usually presented similar findings. In the artery and vein ligature groups (group II), and the arterial ligature group (group III), the bowel was usually not distended, neither was it covered with fibrin. The color in a few cases was grayish yellow (anemic) but the majority of the segments had undergone hemorrhagic necrosis. The wall was of a jelly-like consistency, of a mahogany color, usually thinner than normal and quite frequently perforated in one or more places. The peritoneal cavity usually contained from 100 to 500 cc. of a dark bloody, foul smelling fluid of a high total protein content, in marked contrast to the odorless fluid in the venous strangulation group.

Conclusion. Although the length of bowel involved is of importance in shortening the survival period following strangulation obstructions, the type of obstruction is of greater significance.