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Absorption of Hydrokollag from the Obstructed Bowel.*

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A colloidal suspension of graphite known as Hydrokollag has been employed for the intravital injection of capillaries[1] and for the study of phagocytic cells. When this preparation is injected into the circulation, the black graphite particles are taken up by the reticulo-endothelial cells and may be readily demonstrated within these cells under the microscope. The object of our experiments was to determine whether in bowel obstruction the intestinal mucosa was sufficiently altered to permit of absorption of the graphite. Absorption does not occur in the normally unobstructed bowel. Herrmann and Higgins[2] have already reported absorption of Hydrokollag from the obstructed colon in cases in which there was ulceration of the mucosa.

Three forms of intestinal obstruction were studied in this series of experiments, *viz.*, simple, strangulation, and loop obstruction. Simple obstruction at different levels was produced by dividing the bowel and turning in both ends after having placed Hydrokollag in the proximal loop. Strangulation obstruction was accomplished by tying off a segment of bowel together with its blood supply. Hydrokollag was injected into the lumen of the strangulated segment. In loop obstruction the bowel was divided in 2 places, the 2 ends of the isolated loop turned in after Hydrokollag had been introduced into the loop. Intestinal continuity was re-established by anastomosis of the loops of bowel proximal and distal to the ob-

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1 Drinker, C. K., and Churchill, E. D., *Proc. Roy. Soc. London*, 1927, **101**, 462.

2 Herrmann, S. F., and Higgins, G. M., *Am. J. Med. Sci.*, 1930, **179**, 36.

structed loop. The loop obstruction may be regarded as a form of strangulation obstruction. The amounts of Hydrokollag placed in the bowel in all types of obstruction varied from 20 to 50 cc. Usually 50 cc. was introduced into the lumen of the bowel.

When an animal (dog or rabbit) died or was sacrificed, specimens of liver, spleen and sometimes of the abdominal lymph nodes, kidney or lung were obtained. Eventually paraffin sections were prepared and stained with hematoxylin and eosin and examined microscopically for the presence of graphite particles. Formalin was first employed as the fixative but the not infrequent presence of formalin pigment proved to be a source of confusion. Later Zenker's solution was used for fixing the tissues. However, even when the animals were sacrificed and the tissues immediately fixed in Zenker's solution, black precipitate could be observed on some of the slides when studied under the microscope. The differentiation between graphite and extraneous pigment was in some instances very difficult if not actually impossible. The results reported here include only those experiments in which the tissues were fixed in Zenker's solution shortly after the death of the animal. In most instances the animals were sacrificed and specimens of tissue fixed at once.

The series included 29 dogs and 5 rabbits with intestinal obstruction who died or were sacrificed 1 to 10 days after the performance of the obstructing operation. In 2 additional dogs used as controls, 10 cc. of Hydrokollag was injected into the mesenteric veins. They were sacrificed 2 and 6 days after injecting Hydrokollag into the portal circulation.

Experience with the intraportal injections revealed that the presence of graphite particles within the Kupfer cells of the liver was the most reliable criterion of the presence of graphite in the portal circulation. Therefore, only when black particles appeared to be definitely within these cells were they regarded as absorbed graphite particles.

Results. The accompanying table records the presence or absence of graphite in the liver and abdominal lymph nodes. The tabulated results clearly indicate that under ordinary circumstances Hydrokollag is not absorbed from the obstructed intestine either by way of the lymphatics or the portal circulation. Only in the instance of a loop obstruction which became ulcerated and perforated did any Hydrokollag reach the liver; as some graphite was spilled into the peritoneal cavity as a result of the perforation it may have reached the circulation after having been absorbed from the peritoneal cavity.

TABLE I.
Indicating the presence or absence of graphite particles in the liver and lymph nodes.

	Liver			Lymph Nodes		
	Number	Present	Absent	Number	Present	Absent
Simple obstruction						
Duodenum (dog)	3	0	3	3	0	3
Ileum (dog)	13	0	13	6	1	5
Ileum (rabbit)	5	0	5	—	—	—
Colon (dog)	6	0	6	2	0	2
Loop obstruction	6	1	5	1	0	1
Strangulation obstruction	1	0	1	—	—	—
Controls						
Intraperitoneal injections of Hydrokollag	2	2	0	1	0	1

A very small amount of pigment interpreted as graphite was found in one abdominal lymph node in the case of a dog with simple obstruction of the terminal ileum. In this experiment there was a peritonitis due to slight leakage from the inverted end of the obstructed bowel. In this case, however, the evidence is not complete as to whether the graphite was absorbed from the intestinal lumen or from the peritoneal cavity.

Gross and microscopic examination of the intestinal wall failed to reveal evidence of ulceration in the cases of simple obstruction. The results reported here are, therefore, in accordance with those of Herrmann and Higgins, who failed to note any absorption in the absence of mucosal ulceration when Hydrokollag was placed in the obstructed colon of dogs.

Conclusions. No evidence was obtained to indicate that in high, mid, or low obstruction of the simple type that Hydrokollag was absorbed. These results lend no support to the "absorption of toxins" theory of the cause of death in simple obstructions in which the bowel is viable.