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**Transperitoneal Absorption. VI. Significance of Impaired Viability and Influence of Distension on its Occurrence.\***

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The 3 avenues for absorption of any toxic material from the bowel in simple intestinal obstruction are: the mesenteric veins, the lymphatics and by diffusion through the bowel wall into the peritoneal cavity. It has been shown by many workers that in obstruction, absorption *via* the mesenteric veins is decreased. In another paper we have indicated that lymphatic absorption may be increased by the stasis of obstruction and by increased intra-enteric pressure. We have also indicated in other studies that transperitoneal passage of material probably does not occur unless gross damage to the bowel wall resulting in impairment of its viability is present. Many investigators have emphasized that increased intra-enteric pressure may force toxic material through the bowel wall.

The purpose of this paper is to try to evaluate the occurrence of transperitoneal migration of intestinal content under conditions of obstruction and increased intra-enteric pressure.

Experiments were carried out on: 1. The absorption of strychnine from the normal and obstructed bowel in the intra- and extra-peritoneal location. 2. The effect of increased intra-enteric pressure upon the absorption of strychnine from normal and obstructed bowel in the intra- and extra-peritoneal location. 3. The passage of strychnine through the normal devascularized bowel and through devascularized bowel which had previously been subjected to simple ileal obstruction. 4. The effect of increased intra-intestinal pressure upon the passage of strychnine through the normal devascularized bowel wall. 5. The effect of increased intra-enteric pressure upon passage of strychnine through the bowel wall which had previously been subjected to simple ileal obstruction. 6. The effect of increased intra-enteric pressure upon the passage of dyes through the bowel wall.

1. Simple low ileal obstruction was produced in 12 cats. At intervals of 24, 48, 72, and 96 hours of obstruction, 2 cats were operated on again and 10 mg. of strychnine sulphate was injected into the terminal 3 inches of the obstructed bowel, and the bowel

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\* This work was supported by the Medical Research Fund of the Graduate School, University of Minnesota.

lumen occluded at the site of obstruction by tape ligatures. In one, the loop was returned to the peritoneal cavity and the abdomen closed. In the other, the loop surrounded by warm moist gauze sponges was kept outside the peritoneal cavity, care being taken to avoid compromise of its blood supply. In each experiment the absorption time (interval between injection of strychnine and the onset of convulsive symptoms) was noted. Three normal animals were used as controls to determine the absorption time of strychnine from a normal loop of bowel in both the intra- and extra-peritoneal positions and from the peritoneal cavity directly.

Strychnine was absorbed directly from the peritoneal cavity in 2 minutes. In all of the obstructed animals there was slight but definite delay in increase of absorption time evident within the first 24 hours of obstruction (3 to 6 minutes as compared with 2 to 3 minutes for the normal). This increase of absorption time was more marked when the loops were outside the peritoneal cavity (8 to 13 minutes). In this small series the absorption time seemed to increase directly with the duration of the obstruction.

2. In 4 dogs closed ileal loops 12 inches in length were prepared. A glass cannula was inserted in one end of the loop and after the intra-enteric pressure was raised to 130 mm. of mercury, 50 mg. of strychnine was introduced into the loop. With a pressure maintained over 100 mm. of mercury no absorption could be demonstrated over several hours of observation. Only when the intra-enteric pressure was reduced to approximately 70 mm. of mercury could the strychnine effect be elicited. This occurred whether the loop was in the peritoneal cavity or in an extra-peritoneal location. Two dogs with simple low ileal obstruction of 3 days' duration developed symptoms at 50 and at 60 mm. of mercury when the above experiment was carried out.

When strychnine was introduced into a loop at 100 mm. of mercury and the abdomen closed, convulsions did not develop until the intra-enteric pressure decreased by relaxation of the bowel wall (postural tone) to a level of 75 mm. of mercury at which critical point the strychnine was absorbed *via* the mesenteric vessels.

3. In 4 cats with simple ileal obstruction of 96 hours and one cat with an obstruction of 144 hours' duration, the distal 3 inches of the obstructed gut was devascularized and a large dose of strychnine 10 to 50 mg. was injected into the lumen. Similar devascularized loops were prepared in 5 normal cats as controls. After closure of the abdomen the cats were allowed to come out of anesthesia and observed for signs of absorption of the poison. The obstructed

animals developed convulsive signs within 2½ to 3 hours and were dead or sacrificed within 3 to 4 hours. In contrast, the normal cats did not develop signs of poisoning for 4½ to 7 hours.

4. Closed loops of ileum 10 inches long were prepared in four normal dogs. The loops were devascularized and 50 mg. of strychnine was introduced into the lumen. Two of the loops were distended with air to a pressure above 100 mm. of mercury; the other 2 were not distended. The abdomens were closed. The animals were allowed to come out of anesthesia and were observed carefully for signs of strychnine poisoning. The dogs with the loops under increased pressure developed convulsions within 3 hours. Those in whom the loops were not under pressure remained symptom-free for more than 8 hours.

5. In 3 dogs with simple ileal obstruction of 5 days' duration, closed loops of ileum just above the site of obstruction were made. The intra-enteric pressure was raised to approximately 120 mm. of mercury and 50 mg. of strychnine was introduced into the lumen of the bowel. One dog developed signs of strychnine poisoning in 18 minutes. Examination showed tears of the serosa through to the muscular layers. The second dog developed symptoms in 45 minutes; the third dog did not evidence any symptoms even after 75 minutes. Examination here too revealed numerous tears through the serosa.

6. Freshly excised viable loops of ileum were obtained immediately after death from 2 normal cats sacrificed during the course of other experiments. The loops were filled with 1% trypan blue and subjected to pressures of 50 and 100 mm. of mercury respectively for a period of one hour. Freshly excised loops from 2 cats with low ileal obstruction of 24 and 48 hours' duration were filled with dye and subjected to distension at 40 and 130 mm. of mercury. The dye did not permeate through the bowel wall after one hour of distension. However, when loops from 2 obstructed cats dead 6 and 8 hours were subjected to distension at 100 mm. of mercury, the non-viable bowel wall permitted the dye to permeate directly through it in 15 to 30 minutes. When gentian violet 1% was injected intra-enterally in cats with simple and closed loop ileal obstruction, microscopic section of the bowel wall (Churchman's method<sup>1</sup>) revealed a slight staining of the mucosa in only a few instances. As this was not a constant finding and was present only in the case of cats dead over a period of hours, we must assume that the pene-

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<sup>1</sup> Churchman, J. W., *J. Urol.*, 1924, **11**, 1.

tration of the mucosa was a postmortem phenomenon. In none could transperitoneal passage of the dye be demonstrated by wrapping gauze about the outside of the bowel. In one experiment, the dye was introduced into the loop under very great pressure. When the cat was sacrificed 72 hours later (moribund), several purple spots were visible on the antimesenteric border, which were interpreted as representing non-viable necrotic areas through which the dye passed.

*Summary.* 1. The absorption of strychnine through the mesentery is very rapid even when the loop is outside the peritoneal cavity when contrasted with the absorption time (transperitoneal) when the gut is devascularized. The comparatively slight increase of absorption time in the obstructed loops in the extra-peritoneal position may readily be explained as due to the abnormal location of the loop, slight tension on the mesentery, handling of the bowel, and the accompanying change of temperature which must occur to some extent in spite of attempts to preserve normal conditions. It would appear that obstructed bowel is more sensitive to such changes than the normal.

2. Intra-enteric pressure above the diastolic pressure of the animal (70 mm. of mercury) effectually prevents the mesenteric absorption of strychnine. Such pressures, however, never obtain in experimental or clinical cases of obstruction.

3. From experiments on the devascularized normal and obstructed cat bowel, it appears that the obstructed bowel loses its viability and becomes permeable somewhat sooner than the normal bowel under similar experimental conditions.

4. Devascularized loops of normal bowel permit diffusion of strychnine through the bowel wall in approximately 8 hours and under conditions of increased intra-enteric pressure in approximately 3 hours. Under similar conditions of increased pressure the bowel wall of obstructed dogs becomes permeable somewhat earlier because of tearing of the serosal layers. As shown previously the bowel wall in obstruction is unable to withstand increases of intra-enteric pressure as well as the normal.<sup>2</sup>

5. It is evident that the increased intra-intestinal pressure due to the distension which obtains in simple obstruction is directly responsible for any transperitoneal absorption which might occur. Due to the increased intra-intestinal pressure the bowel wall becomes

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<sup>2</sup> Sperling, L., and Wangensteen, O. H., *PROC. SOC. EXP. BIOL. AND MED.*, 1935, **32**, 1138.

damaged, its viability is impaired and diffusion of toxic material through its walls may occur.

6. Experiments on the diffusion of dyes through the bowel wall are in accord with the experiments on strychnine absorption; viable bowel resists permeation and nonviable or dead bowel is readily permeable.

The work of Gatch,<sup>3</sup> Dragstedt,<sup>4</sup> and others concerning the effect of increased intra-intestinal pressure upon the mesenteric absorption is substantiated. The greater potential for the occurrence of transperitoneal absorption in the obstructed bowel is well shown in the results accompanying devascularization of normal and previously obstructed bowel. Still evidence of transperitoneal absorption does not ordinarily obtain until anatomical evidence of bowel wall damage is demonstrable.

*Conclusions.* 1. Transperitoneal absorption in simple obstruction may occur but only through devitalized segments of bowel subjected to distension. 2. The obstructed bowel under similar experimental conditions is more permeable to strychnine than the normal.

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<sup>3</sup> Gatch, Wm., *et al.*, *West. J. Surg.*, 1932, **40**, 161.

<sup>4</sup> Dobyns, G. J., and Dragstedt, C. H., *Proc. Soc. Exp. Biol. and Med.*, 1933, **30**, 207.