

# ON THE VIABILITY OF THE INTESTINE IN INTESTINAL OBSTRUCTION\*

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ONE of the greatest difficulties encountered in the surgery of intestinal obstruction is the management of gut of doubtful viability. Should it be returned? Should it be resected? On occasions such gut has been returned to the peritoneal cavity in the belief that the circulation would take care of itself. If not, the involved segment could be subsequently removed should alarming symptoms develop. If it is left *in situ* the circulation may return and result in recovery or the segment may become gangrenous with or without rupture and result fatally. Often gut which is apparently not viable has been accidentally or deliberately returned to the abdomen and in some instances the patient recovered.

## CASE REPORTS

CASE I.—SN 9, Male, age sixty-four. Type of obstruction—strangulated right femoral hernia. Pathology found at operation and operative treatment—hernial sac contained several c.c. of serosanguineous fluid and 20 cm. of black gut with strangulated omentum. Omentum resected. Lustre and color returned to segment after application of hot pads sufficiently to warrant its replacement (Plate 1b). Post-operative course—patient died four days after operation with signs of paralytic ileus. Wound inspection—gangrenous segment of gut found. Remarks—viability of the gut questionable, resection considered. Circulation apparently returned but subsequently became impaired resulting in gangrene of the segment.

CASE II.—SN 126, male, age twenty-six. Type of obstruction—intussusception. Pathology found at operation and operative treatment—free serosanguineous fluid in the peritoneal cavity, 60 cm. of ileum telescoped into cæcum and ascending colon. Reduction of intussusception was not difficult. About 10–15 cm. of reduced ileum (intussusciens) appeared dark in color. After applying hot pads the color and luster returned sufficiently to warrant its replacement (Plate 1c). Post-operative course—paralytic ileus and pneumonia developed. The patient succumbed on the eleventh day. Autopsy—pneumonia and a gangrenous segment of ileum 10–15 cm. in length. Remarks—viability of the gut questionable, resection considered. The pneumonia was the obvious cause of death. The question arises however, if the patient would have survived as the circulation after having apparently returned became permanently impaired.

CASE III.—SN 31, male, age sixty-eight. Type of obstruction—strangulated right indirect inguinal hernia. Pathology found at operation and operative treatment—the hernial sac contained several c.c. of serosanguineous fluid and 20 cm. of dark gut. The circulation returned except in two small areas (Plate 1c). Peristalsis observed, gut replaced. Post-operative course—patient died one week after operation following a stormy post-operative course. Wound inspection—segment of gangrenous gut. Remarks—viability questionable, resection considered. Circulation apparently returned except in two small areas but subsequently the entire segment became devitalized.

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CASE IV.—SN 8, male, age seventy. Type of obstruction—strangulated left recurrent sliding hernia. Pathology found at operation and operative treatment—several c.c. of sero-sanguineous fluid and a loop of ileum 30 cm. in length, dark blue in color, caught under a band extending from one portion of the sigmoid to the other. The band was cut, the circulation returned to the segment (Plate 1c). Post-operative course—patient died three days after operation. Wound inspection—gangrenous segment. Remarks—gut became gangrenous after apparently appearing viable.

CASE V.—SN 28, male, age forty-eight. Type of obstruction—volvulus the result of bands and adhesions. Pathology found at operation and operative treatment—about one litre of serous fluid escaped on opening the peritoneal cavity. Several coils of small intestine were dark blue in color. The obstruction was produced by a distinct band extending from site of old epigastric hernia to ileum. The band was cut and ligated. After the application of hot pads the circulation returned to the strangulated loops sufficiently to warrant their replacement (Plate 1d). Post-operative course—patient died ten hours after operation. Wound inspection—serosanguineous fluid and two loops of intestine which were gangrenous. Remarks—viability of the gut questionable, resection considered. The patient was obstructed

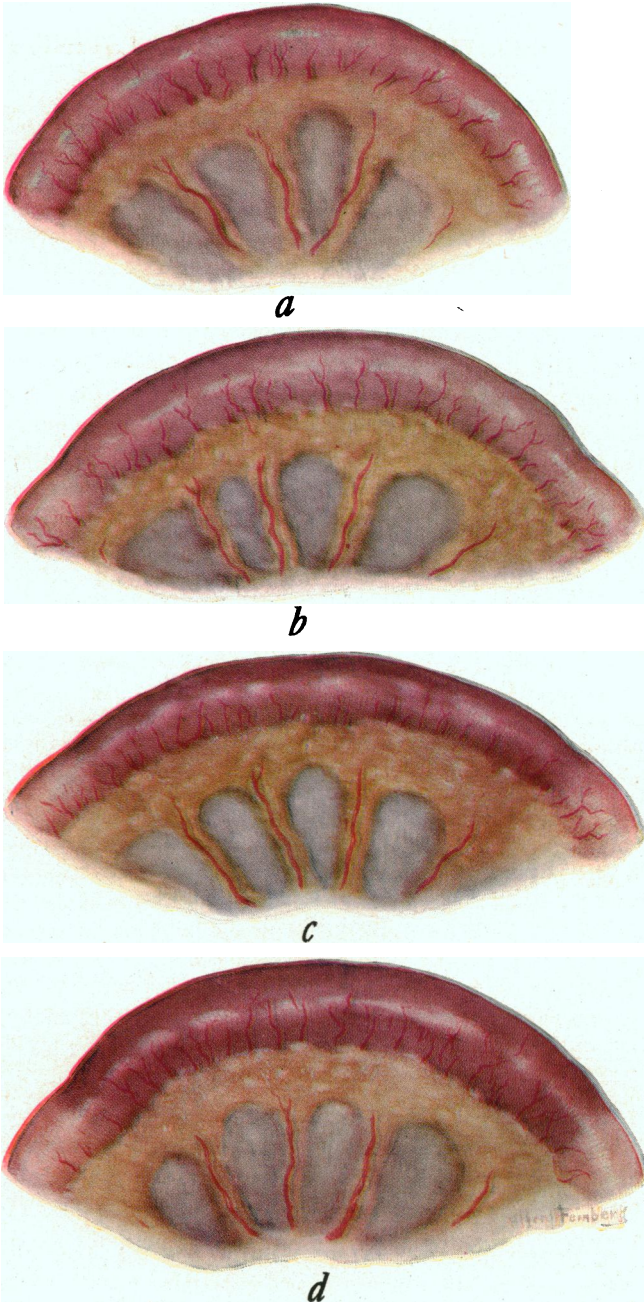


PLATE I.—Intestine of the dog. a. Normal. b, c, d. Degrees of questionable viability.

serosanguineous fluid and two loops of intestine which were gangrenous. Remarks—viability of the gut questionable, resection considered. The patient was obstructed

five days before operation. The loops were apparently viable but subsequently became devitalized.

CASE VI.—SN 32, female, age thirty-one. Type of obstruction—strangulated right femoral hernia. Pathology found at operation and operative treatment—serosanguineous fluid and a segment of intestine 10 cm. in length, black in color were found in the hernial sac. The loop was deliberately returned to the peritoneal cavity. Post-operative course—the patient made an uneventful recovery. Remarks—gut apparently not viable. Circulation was impaired and the segment was deliberately returned to the peritoneal cavity without ill effects.

CASE VII.—SN 6, female, age forty-four. Type of obstruction—strangulated right indirect inguinal hernia. Pathology found at operation and operative treatment—about

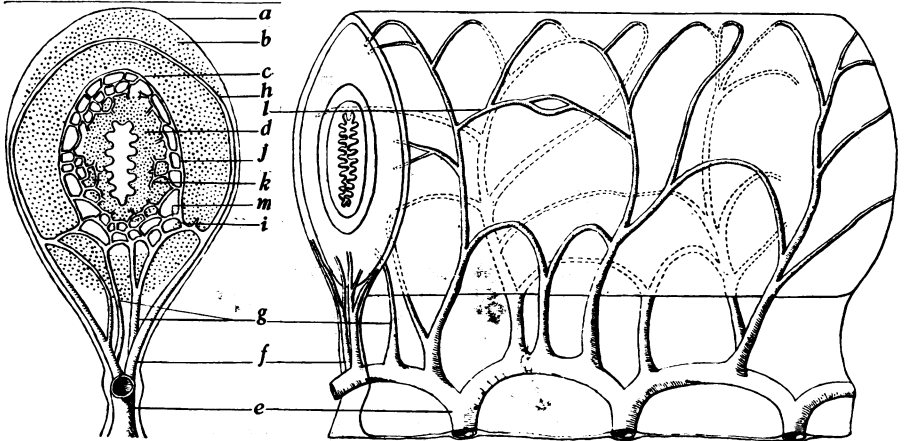


FIG. 1.—Transverse and longitudinal views of intestine (diagrammatic). a, serosa; b, muscularis; c, submucosa; d, mucosa; e, terminal arcade; f, vasa recta; g, smaller arteries at mesenteric border; h, vasa recta piercing muscularis; i, muscular plexus; j, submucosal plexus; k, mucosal plexus; l, lateral anastomosis; m, right-angled vessel to vertical axis of gut.

250 c.c. of serous fluid and three loops of small gut present in hernial sac. One loop was 30 cm. in length and black in color. The other two were congested. While cutting restriction at neck of sac the loop which was black and lustreless accidentally slipped back into the peritoneal cavity, no attempt was made to recover the loop. Post-operative course—the patient recovered after a stormy convalescence. Remarks—gut apparently not viable. The blood chemistry showed an increase in the toxæmia after the obstruction was removed and continued for several days before a return to normal was noted.

In the first five cases the gut was of questionable viability. The degree of circulatory impairment is depicted in Plate I as it appeared in the segments just before they were replaced. (Case I—Plate 1b; Case II—Plate 1c; Case III—Plate 1c; Case IV—Plate 1c; Case V—Plate 1d). Resection was not performed because of a previous personal conception based upon clinical observations that strangulated gut, as described above, recovers. This opinion was strengthened by the viewpoint of other surgeons, who believe that gut will recover unless it is actually gangrenous. Cases VI and VII, in which the gut was apparently not viable, were examples which seemed to justify their contention.

Since there is such uncertainty in the outcome of a strangulated segment of intestine unless it be resected, several questions arise: Is there a factor of safety in the number of vessels that can be impaired with impunity? How

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does the circulation become reestablished in an impaired segment of intestine and why the production of a gangrenous segment in an apparently viable one?

In an attempt to explain the varying results in these cases, the following anatomical and experimental study was undertaken. It has been shown by Dwight,<sup>1</sup> Monks<sup>2</sup> and Mall<sup>3</sup> that there is a free anastomosis in the mesentery and the intestinal wall. The writer<sup>4</sup> has verified these findings and has shown that the vasa recta, while encircling the intestine, give off branches which in anastomosing converge toward the lumen and run more or less parallel to the longitudinal axis of the intestine. The vasa recta are not end arteries. In addition, there are numerous smaller arteries at the mesenteric border which inosculate with one another and the vasa recta, completing a more or less concentric anastomosis. (Figs. 1 and 2). In the large intestine, Rost<sup>5</sup> calls attention to the fact that there is a marginal vessel. In the small intestine the arches of the last arcades also run more or less parallel to the mesenteric border of the gut and can be regarded as a marginal vessel with numerous incoming branches. The fixation of the large bowel compensates in part for the few incoming branches and arcades. The duodenum has a marginal vessel and is partially fixed. Figures 3 and 4 are a diagrammatic representation of the intestinal circulation in the dog and human, respectively. The similarity in the arrangement of the mesenteric circulation is clearly shown.

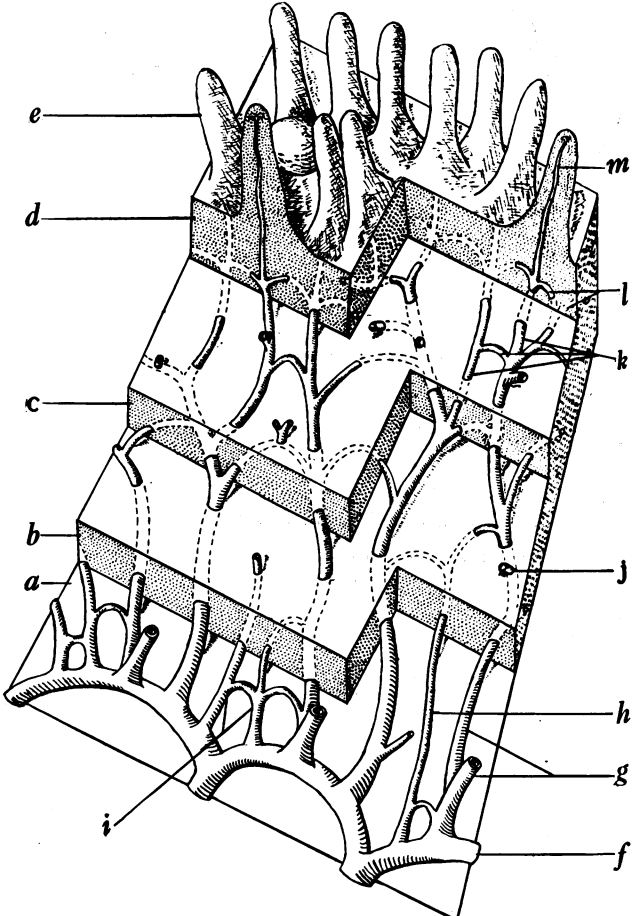


FIG. 2.—Reconstruction of human intestine showing relationship of arteries to intestinal coats (diagrammatic). a, serosa; b, muscularis; c, submucosa; d, mucosa; e, villus; f, terminal arcade; g, vasa recta; h, smaller arteries at mesenteric border; i, anastomosis of smaller arteries at mesenteric border; j, right-angled vessel to vertical axis of gut; k, submucosal plexus; l, mucosal plexus; m, artery to villus.

Thus, recovery should readily follow after strangulation, provided the obstructing agent is removed before gangrene develops. Unfortunately, this is not so. Hence, other factors must be sought.

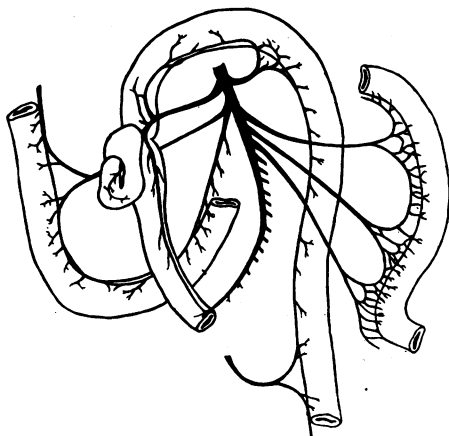


FIG. 3.—Mesenteric circulation in the dog (after O. C. Bradley).

The work of Rydigier,<sup>6</sup> Madelung,<sup>7</sup> Welsh and Mall<sup>8</sup> showed that it was impossible to establish any definite rules as to which vessels of the mesentery of the small intestine could be ligated without danger of gangrene. Similar experiments were carried out.<sup>9</sup> It was found that the margin of safety in the dog was greatest following ligations of vessels of the second mesenteric arcades, Fig. 6b. There is a considerable decrease in this factor after ligations

of vessels of the first arcade, Fig. 5g, or vasa recta, Fig. 5c, d, and Fig. 6f. It is nil following the ligations of the aa intestinalis, Fig. 5f, colic vessels, Fig. 6e, and oblique ligations of the second arcade in which the terminal arch and vasa recta are included. The active return of the circulation after experimental ligations of vessels of the second arcade is readily explained anatomically by the very free anastomosis. In the human this is considerably increased because of the greater number of arcades. Compare Figs. 3 and 4. The lessened factor of safety in the ligations of the vasa recta and smaller vessels at the mesenteric border was not so clear because of a well-established anastomosis in the submucosa and mucosa. (Figs. 1 and 2.)

Anatomical experiments by injecting a pigmented gelatin into segments of intestines with similar ligations gave almost parallel results except in the ligations of the vasa recta. It was found that the fluid carried only in a few instances following the ligation of one vessel and in no instance after ligation of more than one vessel. However, in living tissue three to four vasa recta could be ligated. (See Table I.) Welsh and Mall<sup>8</sup> brought out the fact that if more than 5 cm. of intestine were separated from its blood supply gangrene results. In our experiments, if

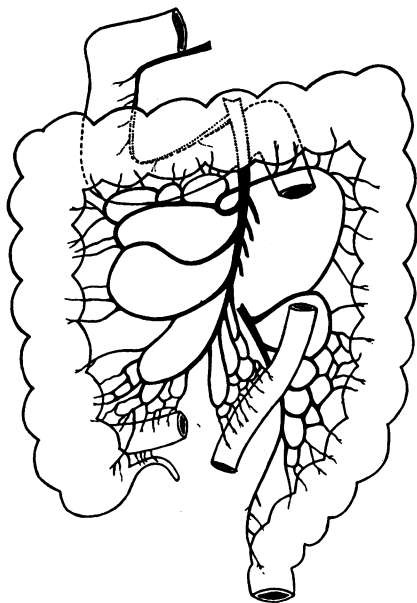


FIG. 4.—Mesenteric circulation in man (diagrammatic).

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the vasa recta and smaller arteries are ligated, gangrene invariably follows if the involved segment is more than 3 cm. of contracted intestine. Mall<sup>10</sup> has shown that 25 cm. of gut shortens to 15 cm. and becomes ischæmic during contraction.

TABLE I

*Showing the Comparative Results Obtained After Ligation of Various Vessels in the Return of the Circulation to a Segment of Gut on Dogs and the Range of Flow of Injection Fluid to the Vasa Recta*

Results of animal experiments	Vessels ligated	Results of injection experiments
N R	aa. intestinalis primary arcade	N R
R	one vessel	R
N R	two vessels	R
N R	three vessels secondary arcade	N R
R	one vessel	R
R	two vessels	R
R	three vessels	R
N R	two vessels (oblique ligation including vasa recta at extremes) vasa recta	N R
R	one vessel	R
R	two vessels	N R
R	three vessels	N R
R	four vessels	N R
N R	five vessels	N R
Circulation returned = R		Vasa recta injected = R
Circulation did not return = N R		Vasa recta not injected = N R

The vasa recta pierce the muscularis in the mesenteric quarters of the small intestine and the anti-mesenteric quarters of the large intestine, Figs. 7a, b. There is a very poor anastomosis in the muscular coats of the intestine.<sup>4</sup> Ligation of the vasa recta at the mesenteric border causes a contraction and spasticity of the musculature supplied. This contracture further constricts the vasa recta in the musculature before they inosculate freely in the sub-mucosa and mucosa, thereby further interfering with the establishment of a collateral circulation. However, there must be another factor, inasmuch as the muscular action does not come into play in the anatomical injection experiments. Apparently there is a mechanical factor of resistance at the anastomosing points where the calibre of the lateral branches from the contiguous vasa recta are smallest.

In all experiments, whether the circulation returned or the gut became gangrenous, the omentum was found wrapped around the strangulated segment. In some cases adhesions were found between the involved segment and normal coils of gut. In those cases in which the circulation returned or became reëstablished microscopic examination showed damage to the intestinal wall. The degree of these changes depended upon the length of time the involved segment was left *in situ* before removal.

*Pathological Report.*—Figure 8, Specimen No. 17—changes due to the ligation of vasa recta. In the mucosa there is an increased number of goblet cells, dead and dying

epithelial cells, debris in the acini and some round-cell infiltration. There is a marked round-cell infiltration in the submucosa and to a less degree in the muscular coats. The muscle layers show degeneration and some fibrous replacement.

Figure 9, Specimen No. 23a—changes due to the ligation of vasa recta. There is greater atrophy of muscle cells with fibrous replacement.

Figure 10, Specimen No. 30—changes due to the ligation of vasa recta. The goblet cells are less in amount. The musculature shows little if any degeneration or fibrous replacement. There is a great increase in fibrous tissue at the serosa.

From these experiments and clinical observations, it is probable that the

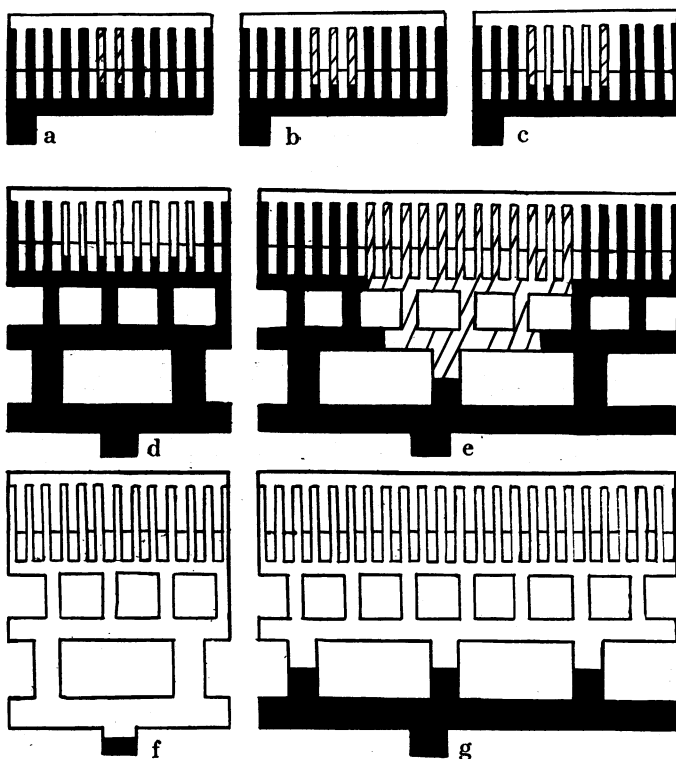


FIG. 5.—Diagrammatic representation of various experimental ligations. Black—no change in circulation. Diagonal lines—return of circulation. White—circulation did not return. a, duodenum—two vasa recta ligated—circulation returned; b, duodenum—three vasa recta ligated—circulation returned; c, duodenum—five vasa recta ligated—circulation returned at extremes of segment—central portion gangrenous; d, jejunum—eight vasa recta ligated—circulation did not return; e, jejunum—one vessel first arcade ligated—circulation returned; f, jejunum—aa intestinalis ligated—circulation did not return; g, jejunum—three vessels first arcade ligated—circulation did not return.

circulation returns in one of the following ways: A return circulation through the original temporarily occluded vessels (clinically); a return or reestablishment of the circulation (clinically and experimentally), the result of a collateral circulation. The development of adhesions between loops of gut and the omentum are beneficial to the recovery of the affected gut.

As yet, there is no evidence of the formation of new blood-vessels through these

adhesions. Clinically, there are cases in which the circulation is apparently in good condition at the time of operation, but later becomes impaired. Here the sudden release of the obstructing agent probably has allowed emptying of the veins with an inrush of blood through the arteries. A momentary return of the circulation is noticed. Soon after the involved area being too large, the damage to the vessel wall too great, associated with a spastic muscular contracture, there is a secondary circulatory impairment. The collateral anastomosis, omentum and adhesions are here insufficient to compensate.

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Clinically, whether a hernia, volvulus, intussusception, etc., the consideration of the treatment of a strangulated loop is the same. The treatment will not be discussed in early cases where the circulation is not impaired and late cases where the gut is gangrenous with an associated paralytic ileus.

The important group is the intermediary type of case in which the viability of the gut is questionable. The terms, early, intermediary and late were based upon experimental data previously published.<sup>11</sup> An early case is one in which the circulatory disturbances have not injured the segment of gut

to any perceptible degree, whereas in a late case the segment of gut has lost its viability beyond repair. In the intermediary class the segment is damaged but not beyond the possibility of repair.

Other factors which must be considered in this classification are the proximity of segment to lethal line in the duodenum, size of the segment and most important, whether the circulation is immediately or gradually occluded. In other words, a strangulated segment 20 cm. in length in which the circulation is immediately occluded, located in the jejunum or ileum, is early within a few hours and late within twenty-four hours. A loop three times as large in the same location with the circulation immediately occluded is late within a few hours. On the other hand, a loop 80 cm. in length through a rent in the mesentery, where the circulation is gradually occluded, is early within twenty-four hours and does not become late until forty-eight to fifty hours, when the circulation is fully occluded. It is obvious that this classification cannot be designated in

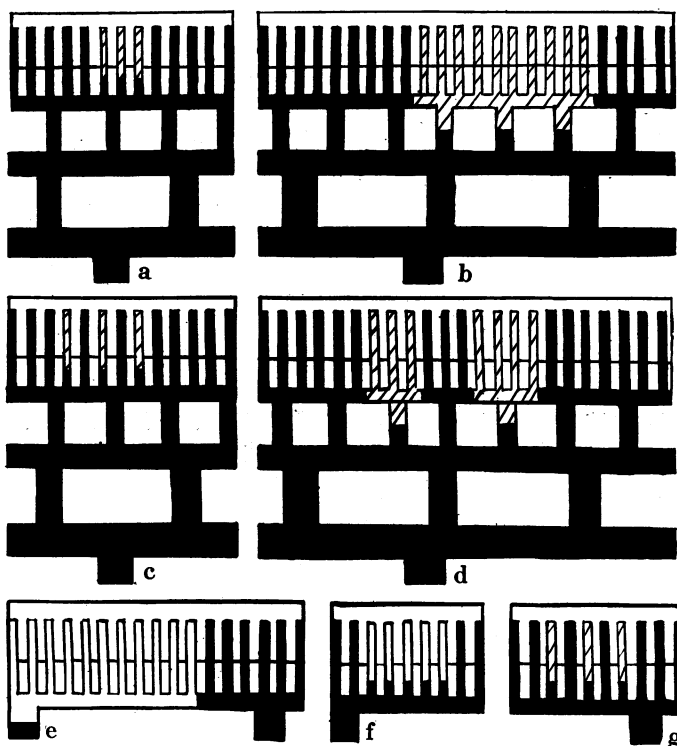


FIG. 6.—Diagrammatic representation of various experimental ligations. Black—no change in circulation. Diagonal lines—return of circulation. White—circulation did not return. a, ileum—two vasa recta ligated—circulation returned; b, ileum—three vessels second arcade ligated—circulation returned; c, ileum—three alternating vasa recta ligated—circulation returned; d, ileum—two alternating vessels second arcade ligated—circulation returned; e, colon—middle colic vessel ligated—circulation did not return; f, colon—five vasa recta ligated—circulation did not return; g, colon—three alternating vasa recta ligated—circulation returned.

It is obvious that this classification cannot be designated in



units of time, but depends upon the above factors which cannot be positively determined until operation.

The intermediary type of case includes those cases in which the circulation has apparently returned sufficiently to warrant the replacement of the intestine and those cases in which the circulation returned sluggishly and apparently is not viable. To consider the gut viable there must be a rather rapid return of the circulation as manifested by color and lustre. The segment may be œdematous but there should be no line of demarcation of color between the normal and the involved intestine. Palpation of the mesenteric arteries as pointed out by Kocher is very important. In addition, the writer palpates the vasa recta at the mesenteric border. The vessels must be pulsating throughout the entire segment and special attention should be paid to the vessels located in the central portion of the segment. The age of the patient with relation to the condition of his arteries is very important. The evidence of general arterial changes makes

resection more of a necessity. If there is any question of doubt, resection with immediate reconstruction is the operation of choice.

CASE REPORT

CASE VIII.—SN 107, female, age twenty-seven. Type of obstruction—volvulus of the small intestine. Pathology found at operation and operative treatment—a segment of gut 40 cm. in length, black in color, was present with serosanguineous fluid in the peritoneal cavity. After removal of the obstructive band and the application of hot pads the circulation returned sufficiently to warrant its replacement (Plate 1d). As a result of previous experience in experimental work resection with an end-to-end anastomosis was performed. Post-operative course—uneventful recovery. Remarks—immediate reconstruction of the canal was decided upon as there were no complications.

If complications are present the segment may be delivered outside the peritoneal cavity with drainage above the obstruction. The segment is later resected. Immediate reconstruction of the canal at this time depends upon the

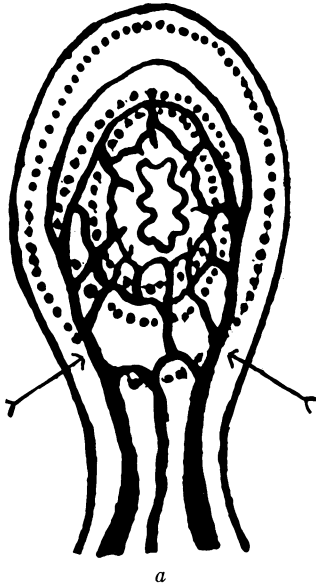


FIG. 7.—a. Longitudinal section of human small intestine. Arrows point to entrance of vasa recta in the mesenteric quarters.

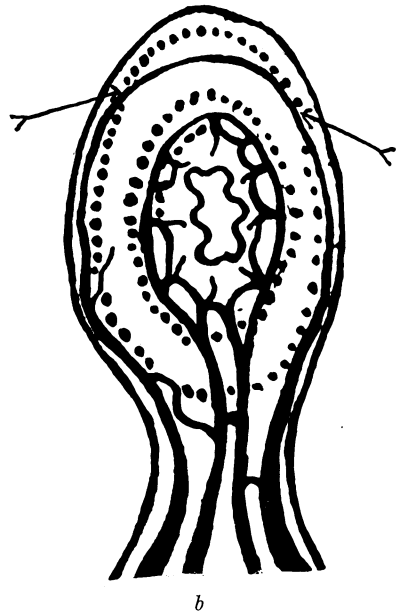


FIG. 7.—b. Longitudinal section of human large intestine. Arrows point to entrance of vasa recta in the anti-mesenteric quarters.

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condition of the patient and the proximity of the segment to the duodenum. The segment is not left upon the abdomen with any thought of allowing a subsequent return of the circulation, but to avoid further operative shock to a patient in poor general condition. Experimentally it has been shown that removal of a devitalized segment, regardless of its location, is essential to the life of the animal. Furthermore, no ill effects result if it is left outside the peritoneal cavity without removing it, provided the oral gut is drained.<sup>12</sup>

### CASE REPORT

CASE IX.—SN 10, female, age twenty-four. Type of obstruction—volvulus of sigmoid complicated with pregnancy at term. Pathology found at operation and operative treatment—segment of colon 80 cm. in length, dark in color, dilated five times its normal size, was found with serosanguineous fluid in the peritoneal cavity. After untwisting the volvulus and repeatedly applying hot pads the circulation slowly returned (Plate 1c). Although the segment was

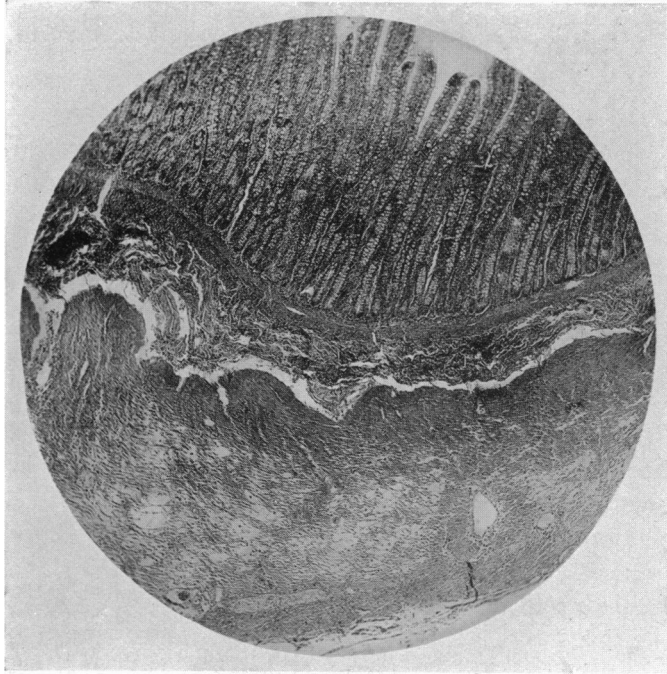


FIG. 8.—Photomicrograph showing effects of ligation of vasa recta.

apparently viable it was left upon the abdomen and a large tube inserted in the oral colon (Fig. 11). Resection was not performed owing to the poor condition of the patient. Twenty-four hours later the segment was devitalized and was resected at the patient's bedside without anaesthesia. Reconstruction of the canal was left for a later date. Several days later the patient was delivered of a dead child at term. Finally after a stormy convalescence the patient recovered. About five months after a lateral anastomosis was performed. The patient succumbed several days later with signs of general peritonitis. Wound inspection—general peritonitis due to a leak at upper angle of anastomosis.

From all the evidence presented, leaving gut of questionable viability in the peritoneal cavity with the idea that it is just as safe to resect within twenty-four hours, is to be condemned. For these twenty-four hours are very important hours in the determination of the prognosis. A fatal toxæmia can result within this time if the segment does not become viable. The fact that a certain number of these cases have recovered in which the circulation

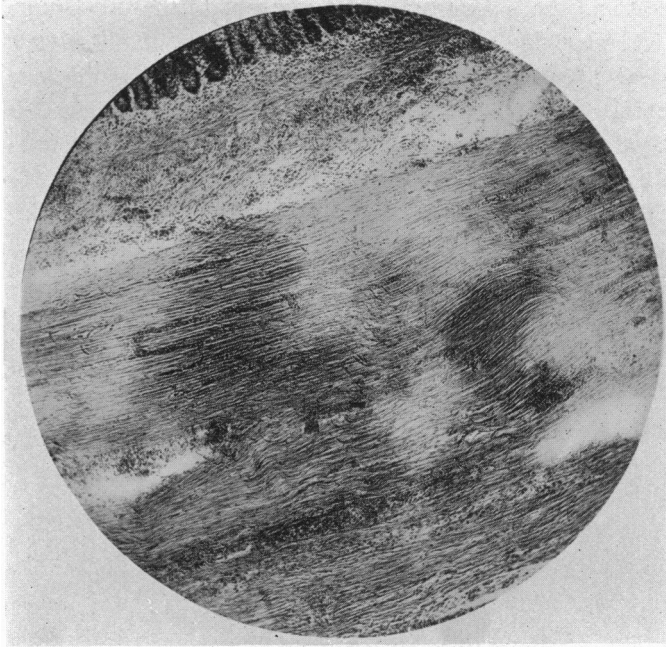


FIG. 9.—Photomicrograph showing effects of ligation of vasa recta.

was impaired at the time of operation and became reestablished should not be a criterion against resection, for a great number of these cases do die from this cause as shown by autopsy.

CONCLUSIONS

1. It is often difficult to determine the viability of strangulated intestine.

2. Although there is a rich anastomosis in

the mesentery and intestinal wall, comparatively slight interference with this circulation causes disproportionately great damage to the intestine.

3. Experimental ligation of the vessels of the second mesenteric arcades is the safest.

4. The circulation returns or becomes reestablished in an impaired segment, either through the temporarily occluded vessels or as the result of a collateral circulation.

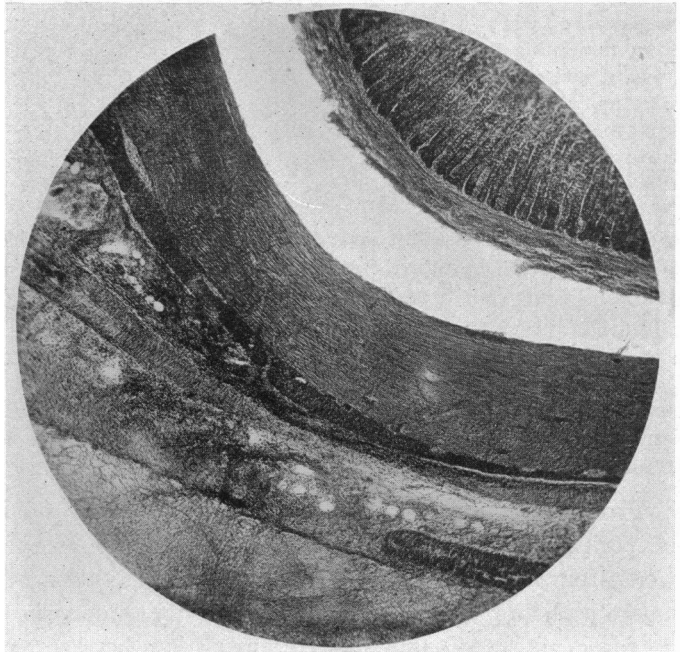


FIG. 10.—Photomicrograph showing effects of ligation of vasa recta.

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5. The circulation does not return and the segment becomes gangrenous if the involved area is too large and there is too great a trauma to the vessels with a prolonged spastic muscular contracture.

6. The classification of strangulated bowel into early, intermediary and late, does not designate units of time. This depends upon the size of the



FIG. 11.—Photograph of Case IX, showing volvulus of sigmoid twenty-four hours after primary operation. a. Oral drainage tube. b. Drainage tube in segment. c. Peritoneal drainage.

segment, its proximity to the duodenum, and whether the circulation is immediately or gradually occluded.

7. In the intermediary type resection with immediate reconstruction of the canal without drainage is the most satisfactory procedure.

8. If systemic complications are present, the involved segment is left upon the abdomen with oral drainage of the intestinal canal. Resection and reconstruction are later performed either in one or two stages.

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