itioner who is not directly connected with a medical-teaching or research institution. His task will be made more easy and more fruitful if he finds a sympathetic understanding on the part of the practitioner. Furthermore, the practitioner might come into closer touch with the work of the investigator, adopting the latter's attitude of mind in those cases in which he is confronted with new situations and new problems in his practice, and at the same time he might add to his usefulness and to the dignity of his position by becoming a source of intellectual and moral help to the community by fortifying himself in his difficult task through the philosophic study of science, and by communicating the spirit of science to the circle of those who are under his care. The realization of this conception will effect a very close union between investigator and practitioner. The physician can be and ought to be thus a bearer of the message that science has for mankind.

Barnard Free Skin and Cancer Hospital.

EXPERIMENTAL DEVASCARIZATION OF SEGMENTS OF INTESTINE WITH AND WITHOUT MECHANICAL OBSTRUCTION *

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Any experimental work dealing with intestinal obstruction as one of its chief features requires a preliminary statement of the present status of obstruction. The exact cause of death in obstruction of the bowel has never been definitely determined. The three theories advanced are: (1) the nervous theory, which holds that the nervous system is affected in somewhat the same way as in shock; (2) the bacterial theory, which holds that death is due to the bacteria contained in the obstructed intestine; (3) the toxemia theory, which holds that death in obstruction is due to some perversion of intestinal metabolism. Metabolic toxins may be formed in the epithelium of the intestine, or the mucosa may permit the direct absorption of peptones and products from the intestine that are normally changed by the epithelium before being discharged into the circulation. The nervous theory has few advocates, but the bacterial theory and the theory of toxemia have many champions.

RECENT EXPERIMENTAL WORK

It is not our purpose to review the literature on this subject, which can be found in a number of recent articles, particularly those by Hartwell and Hoguet,¹ Murphy and Vincent,² and J. W. Draper,³ to say nothing of the German and French work, which in the last few years has been quite extensive. We desire, however, to call attention to some of the deductions made from recent experimental work. It does not seem probable that the chief cause of death in intestinal obstruction is a lesion of the intestinal mucosa as Hartwell and Hoguet believe, though this may be a contributing cause. If a

lesion of the mucosa is chiefly responsible, it would be difficult to explain why the symptoms of ileus do not develop after any ulceration of the bowel, or after any wound in which a raw surface is necessarily left in the mucosa, as in intestinal resection. It has been pointed out by Roger and Garnier and by others that the normal products of intestinal digestion, particularly the peptones, are poisonous if directly injected into the circulation. The intestinal mucosa exerts some chemical change on this material during the process of absorption, which not only renders it non-toxic, but converts it into nutrition for the body cells. Experiments, then, which depend on the fact that material taken from a strangulated loop of intestine and injected into an animal produces illness and death, do not by any means prove that this material is peculiar to the strangulated intestine. The normal products from the normal intestinal tract when injected will also produce marked toxic symptoms and death.

It is generally recognized that a high intestinal obstruction, within 12 inches of the pylorus, is more rapidly fatal than an obstruction low down in the ileum. This is classed by Draper, Roger and Garnier and others as proof of the fact that some vital secretion of the duodenum and no bacterial product is the toxic substance in obstruction, for it is well known that the upper part of the intestinal tract contains fewer bacteria than the lower part of the ileum. The experiments of Murphy and Vincent emphasized this difference in bacteria in the duodenum and the ileum as they found that when material from normal unobstructed bowel of cats was injected within the peritoneal cavity, necropsy revealed a peritonitis which corresponded with the level of the intestine from which the material was taken; that is, the most marked peritonitis was found when the contents of the ileum were used and the mildest when the contents of the duodenum were injected. This does not sustain the theory that the toxic substance is due solely to bacteria, for a low obstruction with a large amount of bacteria should be more rapidly fatal than a high obstruction with a small amount of bacteria.

The fact that the toxic material of obstruction can be reproduced in a section of removed intestine, as was done by Murphy and Vincent, does not exclude the possibility of this material being formed by the cells of the intestinal mucosa. In pathologic conditions of the thyroid gland, as hyperthyroidism, the toxic products may be prepared from the gland after it has been removed and when injected reproduce to a large extent the symptoms of hyperthyroidism. In like manner, a toxic substance might be formed in the intestinal mucosa and extracted after the bowel had been removed from the body, or might be produced by body heat and devascularization, which would be the condition of the intestinal loop placed in an incubator. The careful work of Murphy and Vincent has thrown much light on obstruction, but the rapid death and marked symptoms which they report from intraperitoneal injection of the unsterilized material from an obstructed intestinal loop may be due to septic peritonitis. It is at least conceivable that the peculiar toxic product of acute ileus may be formed from the epithelium of the intestinal mucosa of the obstructed loop under the stimulus of a perverted circulation, of an excessive amount of bacteria, or of both. If toxic products sometimes occur in the thyroid under stimulation of excessive nervous impulses, we cannot dismiss the possibility of some stimulation of the mucosa of the intestine by excessive bacterial toxins or altered circulation causing toxic products here.

* Read in the Section on Pathology and Physiology of the American Medical Association, at the Sixty-Third Annual Session, held at Atlantic City, June, 1912.

1. Hartwell, J. A., and Hoguet, J. P.: *Experimental Study of High Intestinal Obstruction*, Am. Jour. Med. Sc., March, 1912.

2. Murphy, F. T., and Vincent, B.: *Experimental Study of Cause of Death in Acute Intestinal Obstruction*, Boston Med. and Surg. Jour., Nov. 2, 1911.

3. Draper, J. W.: *Experimental Intestinal Obstruction*, THE JOURNAL A. M. A., Oct. 21, 1911, p. 1338.

AUTHORS' EXPERIMENTS

Our experiments were originally undertaken with the idea of determining, if possible, the difference in the effect on an animal when devascularized segments of intestine were obstructed at both ends and when such segments were unobstructed and their products allowed to flow freely into the normal bowel. As the work proceeded other problems arose, such as the ultimate fate of the devascularized segment, the cause of death in obstruction, and the absorption of the toxic material. While no attempt has been made to cover such large subjects as the last two, we have noted everything we

eight hours. The intestine was converted into a jelly-like mass and had ruptured. The omentum was not adherent but was held in position by sutures. In the remaining three experiments in which tapes were used, 2 inches of the intestine were separated from the mesentery and the procedure was the same as in the experiment just described on Dog 4. In these three experiments Dog 2 lived fourteen days; the other two died, one, Dog 5, after thirteen days and the other, Dog 8, after three days.

Of the five that had no tapes one, Dog 3, died twenty-seven days after operation. Necropsy showed that this

TABLE 1.—SEPARATION OF MESENTERY WITH TAPES ON DEVASCULARIZED INTESTINE

No. of Dog	Number of Inches of Intestine Devascularized, and Operative Notes	Postoperative Notes	Length of Life After Operation	Post-Mortem Notes
1	Eight inches. No omentum wrapped around devascularized segment.	Dog looked sick twenty-four hours after operation; abdomen distended; respiration rapid.	Died after 36 hours.	Large amount of bloody fluid; bowel proximal to tapes greatly distended; omentum adherent to abd. incision but not to intestine; segment of bowel black, jelly-like, with large perforation near proximal tape.
2	Two inches. Omentum wrapped around segment of bowel and fastened with silk sutures.	Dog apparently well for four days; for three days quite sick; then better for three days, when he became worse.	Died after 14 days.	No free fluid but coating of lymph on peritoneum; bowel proximal to tape greatly distended, distal firmly contracted; segment of bowel thickened and contracted and surrounded by densely adherent omentum.
4	Two inches. Operation same as in Dog 2.	Dog appeared very sick from time of operation.	Died after 48 hours.	Large amount of free bloody fluid, marked distention of proximal bowel, contraction of distal; omentum adherent to abd. wall but not to bowel; segment black, jelly-like; large perforation.
5	Two inches. Operation same as in Dog 2.	Dog did well for three days, then appeared very sick for one day; again seemed better until two days before death.	Died after 13 days.	No free fluid; no distention of intestine either above or below tapes; omentum firmly adherent to segment, which showed but little change. The coats of this segment are somewhat discolored and swollen but sharply outlined. Evidently the omentum has preserved the nutrition of the devascularized intestine.
8	Two inches. Operation same as in Dog 2.	Dog appeared quite sick from time of operation.	Died after 3 days.	Small amount free bloody fluid; proximal bowel distended; omentum adherent to segment of bowel, which was dark, reddish and thickened.

could in our experiments that might have any bearing on these features of intestinal obstruction.

We have done ten experiments, all of them on dogs. As far as possible the conditions under which each experiment was performed were similar. The dogs had no food for two days before being operated on, though they had water freely. All had water freely but no food after operation except two, Dog 9 and Dog 10, and to them food was also given freely for ten days before they were killed. The experiments were done under full ether anesthesia and with the usual aseptic precautions. Every effort was made to reduce the amount of pain and suffering to the minimum. In no instance was there any evidence of inflammation in the abdominal incision, the wound always healing by first intention. In all of these experiments the mesentery was cut after doubly ligating it in sections at the border of the intestine. In five experiments tapes were applied at each end of the devascularized segment to obstruct, but not injure, the bowel and so cut off its lumen from the healthy intestine (Table 1). In all experiments the last part of the ileum was used. In one instance, Dog 1, there was no effort to protect the intestine with omentum. Here the mesentery was separated for a length of 8 inches. The dog was quite sick from the time of operation and died within thirty-six hours. Necropsy showed that the affected intestine had become gangrenous and was mostly converted into a jelly-like mass which had ruptured and extruded its contents into the peritoneal cavity. In Dog 4 the experiment was similar to that in Dog 1, except that only 2 inches of the intestine were devascularized and the omentum was wrapped around this segment and fastened in position with sutures. The omentum also covered the tapes and extended over on the intestine on each side about 1 inch. This dog also was sick soon after operation and died within forty-

dog had obstruction just above the devascularized segment, where a large hair-ball had accumulated. The obstruction was caused by adhesions and volvulus. There was no perforation. In this dog and in two others of this series of five about 2 inches of intestine were devascularized according to the method mentioned above. Of these two one, Dog 7, was in excellent condition when killed and had apparently lost but little weight. The other, Dog 6, was considerably emaciated. Necropsy showed the intestines in Dog 7 in good condition. The nutrition of the segment was well carried on by the very adherent omentum. In Dog 6, killed twenty-two days after operation, necropsy showed no perforation; but the intestine was quite thin and gave evidence of malnutrition. In none of these three dogs was any food given after operation, so in order to test the nutrition of the bowel more thoroughly two other dogs were operated on by similar technique, except that in Dog 9, 4½ inches, and in Dog 10, 4 inches were devascularized instead of 2 inches. The omentum was wrapped round as in the other cases. These dogs received food, Dog 10 at the end of five days after operation, and Dog 9 at the end of eight days after operation. Each was then given food and water freely for ten days. In neither instance was there any indication whatever of obstruction and the dogs were gaining weight quite rapidly when killed.

In considering the points brought out by these experiments they may be divided into: (1) the nutrition of the devascularized segment; (2) the cause of death; (3) the absorption of the toxic products; (4) the practical deductions that may be applicable to clinical surgery.

NUTRITION OF DEVASCULARIZED SEGMENT

Of the five dogs in which the segment of intestine was devascularized and tapes applied, two died within

forty-eight hours. Of those that lived, one died after three days, one after thirteen days and one after fourteen days. Necropsy in Dog 2, that lived longest, showed that the intestine between the tapes was densely adherent to the omentum and had become thickened and contracted. Its coats were distinct and apparently well nourished, though slightly darker in color than normal. There was some distention of the intestine proximal to the upper tape. In Dog 8, which died after three days, the omentum was found closely adherent to the devascularized intestine. The intestine between the two tapes was very thick, dark red in color, somewhat distended and contained a brown, foul-smelling material. In Dog 5, which lived thirteen days, there was but little change in the segment of bowel, though the only nutrition possible must have come from the adherent omentum. In the dogs in which no tapes were applied the results were interesting. As has been mentioned above, in three of these five 2 inches of intestine were devascularized and in two 4 and 4½ inches were devascularized. In the last two food was given freely for the last ten days without any deleterious effect. All of these five dogs lived and were in good condition when they were killed, except Dog 3, which died from obstruction. The intestines of the others, including those that had food and in which 4 inches or more were devascularized, were in excellent condition and showed little evidence of lack of nutrition.

If the omentum becomes closely adherent it appears to be capable in many instances of nourishing the segment of bowel. If this does not happen the bowel becomes necrotic and perforates and the dog dies within a few hours of septic peritonitis. The question of dosage has much to do with these cases, of course, as segments of more than 2 inches would most likely develop

devascularized segment when the lumen is unobstructed; or again, to the fact that the tapes cut off some nutrition from each end of the segment.

ABSORPTION OF TOXIC PRODUCTS

The dogs with tapes lived a much shorter time than those without tapes. If any peculiar toxic substance was formed in the gangrenous intestine it should apparently be swept on and absorbed if the lumen is unobstructed and should produce more serious symptoms than if the lumen had been closed with the mesentery severed. This, however, is not borne out by these experiments and the result seems to correspond with experiments of Murphy and Vincent, which show that this toxic material is not absorbed from the healthy mucosa. In our own experiments no attempt was made partially to obstruct the circulation of a loop of bowel, but in every instance the total circulation was cut off by double ligatures of the mesentery near the intestinal border. Consequently we have no observations on obstruction to the venous circulation only, which, according to Murphy and Vincent, seems so rapidly fatal.

PRACTICAL DEDUCTIONS

The view usually held that bowel with impaired nutrition can be easily permeated by bacteria has not been borne out in our experiments. In no instance did the dog die under three days except when perforation had occurred and the bacteria and other intestinal contents were thrown in an overwhelming amount into the abdominal cavity. In such cases death took place in a few hours.

A short segment of intestine in a dog, when deprived of its nutrition, if thoroughly protected by omentum,

TABLE 2.—SEPARATION OF MESENTERY WITHOUT TAPES ON DEVASCULARIZED SEGMENT

N ^o . of Dog	Number of Inches of Intestine Devascularized, and Operative Notes	Postoperative Notes	Length of Life After Operation	Post-Mortem Notes
3	Two inches. Omentum wrapped around segment and sutured intestine.	Dog looked sick day after operation; recovered and was better until two days before death; no food.	Died 27 days after operation.	Dog much emaciated; no free fluid in abdomen; segment adherent and in a partial volvulus, causing mechanical obstruction; segment well nourished; intestine above segment dilated and filled with hair for about two inches.
6	Two inches. Omentum wrapped around segment and sutured intestine.	Dog did well; never very sick; no food.	Killed 22 days after operation.	Dog much emaciated; segment very adherent; bowel proximal to segment dilated and contained fecal matter; distal bowel contracted, but contained fecal matter also; segment dilated, very thin, but no perforation.
7	Two inches. Omentum wrapped around segment and sutured intestine.	Dog never appeared sick; no food.	Killed 21 days after operation.	Dog fairly well nourished; segment buried in mass of adherent omentum and mesentery; segment well nourished; no evidence of obstruction.
9	Four and a half inches. Omentum wrapped around segment and sutured intestine.	Dog never very sick; no food for eight days; then food given freely for ten days.	Killed 18 days after operation.	Dog in fair condition; omentum adherent to segment; otherwise there were few adhesions; vessels in adherent omentum much enlarged; nutrition of segment apparently normal; no evidence of obstruction.
10	Four inches. Omentum wrapped around segment and sutured intestine.	Dog never very sick; no food for five days; then food given freely for ten days.	Killed 15 days after operation.	Dog in fair condition; omentum adherent to segment; otherwise very few adhesions; vessels in adherent omentum were enlarged; nutrition of segment good; no evidence of obstruction.

such a large amount of toxic material and be such a tax on the nutrition supplied by the omentum that a fatal result would follow more regularly.

THE CAUSE OF DEATH

In the series of Table 1 death is due either to septic peritonitis or to obstruction of the bowel. Septic peritonitis resulted fatally in a few hours. In the devascularized intestine without tapes, that is, without mechanical obstruction, there was no perforation. This may be due to the fact that saprophytic germs form gas and produce marked distention in the segment that is closed; or that the normal intestinal contents sweep away some of the excessive bacteria and toxins of the

may be nourished through the omentum and maintain its integrity. It has been taught that if even a small portion of intestine becomes detached from its mesentery, gangrene and a fatal result necessarily follow. In a dog this does not appear to be true. The occurrence of mechanical obstruction along with gangrene, as would occur in many clinical cases such as strangulated hernia, intussusception and volvulus, adds a great deal to the gravity of the situation. Devascularization of a segment of bowel without obstruction, as when the intestine is severed from its mesentery by a wound, seems much less serious than when there is obstruction. If such a segment is short and is protected by omentum, the condition appears to be compatible with recovery.