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Mechanism, diagnosis and treatment of adynamic ileus

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THE MECHANISM, DIAGNOSIS AND TREATMENT OF ADYNAMIC ILEUS

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INTRODUCTION

The purpose of this paper is to show the advancement in the knowledge of the mechanism, diagnosis, and treatment of adynamic ileus in the past ten years.

Adynamic ileus is a common disorder. Practically every surgical ward will have one or two patients all of the time who will have postoperative ileus. Since it is a common occurrence, then I think we should understand it well enough to treat it.

In the past ten years the method of treatment of adynamic ileus has been revolutionized. Consequently, the very high mortality of this condition has been considerably reduced.

Also, there is a personal element involved. In December of 1933 and January of 1934, I was confined to bed in a small outstate hospital, because of adynamic ileus following an appendectomy.

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J. Dewey Bisgard, (1), on adynamic ileus states that the terms "adynamic ileus" and "paralytic ileus" are used to designate a condition characterized by distention and relative inactivity of the bowel, as implied by the latter term. There prevails an opinion that the condition is the result of paralysis of the bowel. This is ~~is~~ implied also in much that has been written, and there have been statements from sources of authority that intestinal motor activity is totally or virtually suspended for many hours or even days after abdominal operations. These opinions, as will be shown, are not supported by factual evidence, either clinical or experimental.

As to clinical evidence, our interest in the subject was aroused by experiences with the Miller-Abbott tube. It was observed that this tube traveled down the small bowel as readily and rapidly in the patient with so-called paralytic ileus as in the patient wil normal intestinal function. Obviously, for a state of paralysis this phenomenom presents an incongruous situation. For a logical explanation it must be assumed that in a state of ileus the stretching of the bowel wall from distention is in a large measure responsible for the

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lack of motor activity. It is a well known fact that overstretched muscle loses much of its ability to contract. Furthermore, the function of the muscles is much impaired by the relative state of ischemia which results from the stretching of the blood vessles in the wall of the bowel. As the stretching is relieved by deflating the bowel through the indwelling tube, motor activity is promptly resumed. This we have verified by the fluoroscopic examination of two patients who were given barium sulphate orally after the Miller-Abbott tube had traveled a few feet down the small bowel.

Another incongruous situation is observed in the relief of ileus which may follow the paralysis induced by spinal anesthesia. Here is presented the paradoxical situation of relieving paralysis by inducing paralysis. From this bit of evidence the probable mechanism of ileus may be conjectured. By inducing paralysis, spinal anesthesia presumably releases the inhibiting action of the dorsolumbar sympathetic nervous system on the motor activity of the bowel and leaves the vagus unopposed. It is probable, therefore, that ileus results, at least in part, from an unbalance between the antagonistic actions of the dual innervation of the bowel.

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Complete paralysis of the bowel does occur in the presence of diffuse or generalized peritonitis, and it is our opinion that the term, paralytic ileus, should be reserved and applied only to this condition.

Experimental Observations

The motor activity of the stomach and the bowel is enormously influenced by many factors. Some of these, such as emotional influences, are difficult or impossible to control. For this reason, studies of motor activity are subject to gross errors of interpretation, and from them conclusions can be drawn only in those instances in which controlled factors of influence repeatedly produce the same or consistent responses. With this as a criterion, the following observations are reported:

As in some studies previously reported, continuous kymographic recordings were made of gastric and intestinal motor activity. These recordings registered the varistions in pressure exerted on indwelling compressible rubber balloons by the peristaltic contractions of the viscera studied. Variations of pressure on these inflated balloons were transmitted through the Miller-

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Abbott tube to which they were attached and thence through " " manometers containing bromoform to ink writers which inscribed the records. The apparatus with a balloon in the ileum passed through an ileostomy stoma. For recording the activity of the large bowel, the balloons were introduced through colostomy stomas, and for recording the activity of the stomach and small bowel, they were introduced by means of naso-esophageal intubation.

Ileus Associated with Peritonitis

Records were made in two cases of ileus associated with diffuse peritonitis. Brief histories follow:

Case 1. A man, aged 66, came under observation with diffuse peritonitis, resulting from appendicitis, of four days duration. Death ensued twenty-eight hours later. The nonoperative treatment instituted included the passing of a Miller-Abbott tube for the purpose of applying continuous suction. The tube passed through the pylorus and was observed through roentgenograms to have passed some distance down the small bowel. Records made eighteen, twelve and six hours before death showed complete absence of motor activity.

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Case 2. A man, aged 26, critically ill with a strangulated internal hernia, a gangrenous loop of ileum and definitely established diffuse peritonitis, was operated on after one and one-half hours had been devoted to intravenous hydration therapy, a blood transfusion, and continuous gastric suction. At operation the gangrenous loop was exteriorized and resected between clamps--the two ends being left as ileostomy stomas. The proximal clamp was removed after forty-eight hours, and recordings through this stoma were made daily. For two days there was no evidence of motor activity. On the fourth postoperative day the pulse rate was much reduced, the abdomen much softer and, in keeping with this evidence, the resolution of peritonitis and fairly vigorous though infrequent peristaltic contractions were recorded.

Since it had been observed in the studies mentioned that the normal bowel made definite responses to thermal influences, it was decided to test the response of this infirm bowel to the same agents. As in the normal bowel the application of ice packs to the abdominal wall caused a prompt increase in tonus and in the frequency and amplitude of peristaltic contractions. The application of hot packs to the abdominal wall completely

inhibited motor activity. Taking ice water by mouth likewise inhibited it, while ingestion of hot water increased it.

Postoperative Ileus

In previous reported studies it was shown that the motor activity of the stomach and the bowel both during and after operation was influenced as much by the preoperative and postoperative medication and anesthesia as by operative trauma; also that the various anesthetics varied much in their effects on gastro-intestinal motor activity. Ether, nitrous oxide and barbiturates have an inhibiting action, while spinal anesthetics, cyclopropane and avertin with amylene hydrate have either a stimulating effect or no appreciable effect.

Recordings of the activity of the bowel in six patients, made during and at frequent intervals after clean and uncomplicated abdominal operations performed with one of the noninhibiting anesthetics, at no time showed complete abolition of peristaltic activity and showed reduced activity for not more than twelve hours.

Case 3. A man, aged 58, with an obstructing carcinoma of the rectosigmoid junction, was relieved of

obstruction by a cecostomy, and eight days later the rectum was resected in one stage with the patient under spinal anesthesia. The day before the resection was done, a Miller-Abbott tube with a balloon was threaded into the ascending colon through the cecostomy stoma, and immediately after operation recordings of the activity of the ileum and colon were made simultaneously. In recordings made thirty minutes and three hours after operation, motor activity, although of subnormal vigor, was definitely apparent. Twelve hours after operation and thereafter, both ileum and colon showed activity in excess of normal.

While these studies were being carried out only one patient with uncomplicated and obstinately adynamic postoperative ileus was available for study:

Case 4. An obese woman, aged 52, was operated on to relieve strangulation of a long loop of the ileum in an umbilical hernia. An alarming degree of distention developed fifty-two hours after operation, despite the application of constant suction through a Miller-Abbott tube in the proximal portion of the small bowel. This tube, which had been passed into the stomach before operation, was threaded through the pylorus into the jejunum

at operation. Repeated enemas and 2 minim, (0.1 cc.), doses of pitressin gave meager results. Finally a copious evacuation with a satisfactory diminution in distention followed the application of hot packs to the abdominal wall and the administration of 1 cc. of pitressin.

Records made during this period showed rhythmic peristaltic contraction to be present, though it was feeble. After the administration of the small doses of pitressin, there was a slight increase in tonus and in the duration and amplitude of the segmental contractions. After the large effective dose there was a big increase in tonus and in the amplitude and duration of peristaltic contractions. Obviously the muscularis of the bowel in this case was capable of vigorous contraction when effectively released from inhibition and stimulation.

In two cases the motor activity of the proximal portion of the jejunum immediately following gastrojejunal anastomosis was studied. In both cases an anterior Polya operation had been performed; in one a gastric carcinoma was resected and in the other a gastric ulcer. In each case, after the anastomosis had been completed the ballooned tip of the Miller-Abbott tube, which had been passed into the stomach previously, was threaded

through the stoma into the distal loop of the jejunum for a distance of ten or twelve inches. A second, (Levin), tube, introduced into the stomach through a gastrostomy opening in the stump, was also threaded through the stoma and down the distal loop of the jejunum for a distance of approximately sixteen inches. Through this tube hourly jejunal feedings were administered, being begun immediately after operation. Records of motor activity of the jejunum were obtained by means of the inflated balloon placed just proximal to the point where the feedings were delivered. The records showed that the motor activity, which was barely perceptible one hour after operation and increased but feeble two hours later, was fairly active within nine hours, normal in five days and hyperactive seven days after operation. Immediately after each feeding, there was an increase in tonus and peristaltic activity.

An adequate explanation for the failure of a prompt return to normal motor activity in the foregoing two cases is not immediately apparent. There is good reason to believe that both the vagus and the sympathetic innervation of the bowel were much disturbed during the execution of gastric resection. There is also a theory

that the stomach acts as a pacemaker for much of the intestinal tract.

Thermal Influences

A detailed account of the influence of hot and cold applications on gastric and intestinal motor activity and on the secretion of hydrochloric acid was made in a previous communication. A brief summary of these data follows. After establishing for each patient studied reasonably normal tracings from balloons indwelling in the stomach and the small and large bowel, the following influences were brought to bear at successive periods of observation: (1). The abdominal wall was completely covered with hot water bottles for thirty minutes; (2). The abdominal wall was covered with ice bags for thirty minutes; (3). Both thighs were covered with hot water bottles for thirty minutes; (4). Both thighs were covered with ice bags for thirty minutes; (5). Hot water was administered orally; and (6). Ice water was administered orally. During the period of recording the motor activity of the stomach, samples of the gastric content were aspirated and analyzed for acidity.

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Complete series of records were obtained of responses of the stomach in eight patients, of the small bowel in six and of the colon in four. The responses were sufficiently consistent to be reported collectively as typical of the organ and the experimental factor. Heat applied to the abdominal wall inhibited motor activity of the stomach, the small bowel and the colon. Conversely, cold stimulated tonus and peristaltic activity. When heat or cold was applied directly to the wall of the stomach by having the patient drink hot or cold water the responses were reversed. Heat stimulated and cold had a slightly inhibiting effect on both gastric and intestinal motor activity. Hot applications on the thighs had no effect, and cold ones influenced on the stomach—producing a moderate motor response. Cold applications on both abdominal wall and thighs caused a big increase in both free and total hydrochloric acid.

From the physiologic data mentioned there may be obtained some guidance for the proper clinical uses of hot and cold applications, If it is beneficial, as is generally believed, to inhibit the motor activity of the gastro-intestinal tract and thereby place it at rest as far as possible in the presence of inflammatory lesions--

such as appendicitis and peritonitis--and of bleeding lesions--such as bleeding peptic ulcer--then hot applications and not ice bags are indicated. In the case of peptic ulcer, the increase in gastric acidity following cold application to the abdominal wall also is undesirable.

During the past two years we have lavaged the stomach with ice water in four cases of actively bleeding ulcer. Either because of or in spite of this therapy, the bleeding promptly ceased in three cases. Theoretically, direct chilling of the wall of the stomach should produce vasoconstriction, (of bleeding vessels), in addition to lowering acidity and inhibiting motor activity.

The increase in gastric acidity which follows chilling of the body surface may explain the recurrence of peptic ulcer in the fall and the spring, when there are rapid and radical changes in temperature.

Throughout this discussion the term motor activity has been used and the term motility avoided. The records measured only peristaltic activity and tonus. Motility refers to the movement of gastric and intestinal contents, and this is dependent not only on peristalsis,

but on the patency of the sphincters and on coordinated activity between adjacent segments of the stomach or the bowel. Peristalsis is ineffectual when disorganized. In the normal process of both segmental and mass movements of intestinal contents the various segments of the bowel contract and relax alternately in well integrated fashion. As a given segment contracts and expels its contents the adjoining distal segment relaxes to receive it. Failure of this distal segment to relax not only interferes with the normal movement of intestinal contents, but gives rise to cramp-like pain, such as colic and gas pain. Hot applications are more effective than cold ones in relieving gastro-intestinal cramps, because their inhibiting effect relaxes spasm and thereby facilitates coordinated activity.

In regard to the first fluids taken by mouth by patients after operation, we have observed no difference in the response to cool and to warm fluids except that cool ones are more palatable. Ice water, however, is definitely less well tolerated.

According to Bisgard and Nye, (2), normally the motor activity of the gastro-intestinal tract varies tremendously from minute to minute and hour to hour.

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It is acutely sensitive to widely varied influences and is stimulated or inhibited by such factors as the emotions, the reactions to associations with the senses of sight, taste and smell, the physical states of sleep and fatigue, and the direct factors of hunger and ingestion of water and food. Since some of these influences. notably the emotions, cannot be controlled, studies of motor activity are subject to gross errors of interpretation. Since, however, the responses which followed the applications of hot and cold were consistently characteristic in pattern in repeated observations, they have been interpreted the results of experimental factors. These responses may be summarized as follows: Heat applied to the abdominal wall inhibited motor activity of the stomach, small bowel and colon. Conversely, cold stimulated activity. When applied directly to the wall of the stomach by the temperature of the water drunk, the response to these thermal agents was reversed. Heat stimulated and cold had little or no effect upon both gastric and intestinal motor activity.

Applied to the thighs heat had no effect and cold influenced only the stomach, where it produced a moderate motor response. Hot applications did not alter

the acidity of the gastric contents, while cold ones caused by increases in both free and total acids. Since the application of cold to the thighs, as well as to the abdomen, produced an increase of both gastric acidity and motor activity, it is probable that the increase in acidity was responsible for the motor response. It has been demonstrated by Horton and Brown and others that the chilling of body surfaces causes the liberation of histamine, or a histamine-like substance. The stimulating effect of histamine upon gastric secretions is well established and utilized clinically. This it may be possible that the increase in gastric acidity following the application of ice resulted from histamine liberated by this application.

Conclusions.

1. Gastro-intestinal motor activity is inhibited by the application of heat to the abdominal wall and iced water taken by mouth. It is stimulated by the application of ice to the abdominal wall and by the ingestion of hot water by mouth.

2. External cold applications increase gastric

acidity, increasing both free and total acids. In a subsequent publication it will be proposed that this response be utilixed in the test for true achlorhydria. By simply immersing the hands in iced water for a few minutes, a response similar to that resulting from the subcutaneous injection of histamine can be obtained.

3. The ingestion of iced water diminishes the secretion of acids by the stomach.

Partridge (19) states that adynamic or paralytic ileus can be defined as a symptom complex consisting of pain, nausea, vomiting, distension and obstipation of the gut. Ileus is derived from a Greek verb meaning to twist. Adynamic ileus means lack of physical strength. There is no mechanical hindrance to movement of intestinal contents. There are in adynamic ileus changes either in the nerve supply or changes in the bowel walls so that normal movements of the intestines are interferred with. The term, paralytic ileus is more or less a misnomer. Some authors prefer to call it intestinal incompetence. Others prefer to call it a "flat gradient" because there is a leveling of all the intestinal gradients and in experimental adynamic ileus in animals there is no paralysis of the gut.

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Ochsner and Gage have classified this type of ileus as to causes:

I. Intra-abdominal

- A. Peritoneal irritations.
  - a. Traumatic.
    1. Post operative.
    2. Penetrating wounds.
  - b. Bacterial.
    1. Peritonitis.
  - c. Chemical.
    1. Extravasation of blood.
    2. Perforated peptic ulcer.
    3. Bile peritonitis.
    4. Acute appendicitis.
- B. Vascular Changes.
  - a. Strangulation.
    1. Intra-mural distension following mechanical ileus.
    2. Extra-mural compression of mesenteric vessels.
  - b. Mesenteric thrombosis.
- C. Extra-peritoneal irritation.
  - a. Hemorrhage.
  - b. Infection.
  - c. Renal.

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II. Extra-abdominal.

A. Toxic.

a. Pneumonia.

b. Uremia.

c. Empyema.

d. Systemic infection.

B. Neurogenic.

a. Injuries to and diseases of the spinal cord.

b. Lead poisoning.

c. Fracture of lower ribs -- irritation of nerves.

Traumatism and exposure during the operation are very important factors. Paralytic ileus is due to a newly developed peritonitis either traumatic in origin; use of large packs, rough handling, etc., or to causes which have been pre-existant at the time of operation. There are of course individual variations in response to trauma but the degree of adynamic ileus following an operation is directly proportional to the intra-peritoneal trauma and manipulation.

The toxins are believed to cause a hyperstimulation of the splanchnic nerves. Stimulation of the splanchnics causes inhibition of the intestinal activity. Experimentally it has been shown that a division of the splanchnics prevents adynamic ileus. There are two main origins of the splanchnic nerves: I. The major arises

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from five to nine inclusive dorsal ganglia and extend through the diaphragm to coeliac ganglia behind the pancreas. II. The minor arises from the tenth to twelfth thoracic ganglia and also extends through diaphragm entering coeliac ganglia near the renal arteries. III. From the coeliac ganglia branches are sent to various plexuses chiefly the superior and inferior mesenteric and renal.

Green (9) says that ileus may be divided into:

1. Mechanical Ileus in which there is a definite mechanical obstruction to the lumen of the bowel, such as occurs in carcinoma, bands, volvulus, intussusception and foreign bodies in the lumen.
2. Strangulation Ileus in which the vessels are involved as in embolism or thrombosis. Any mechanical type becomes this type when the blood supply is interfered with. Paralytic types of ileus may likewise present similar pictures when the vessels become involved.
3. Adynamic Ileus in which the musculature of the bowell wall is paralyzed, as in peritonitis, torsion of the pedicle of ovarian cysts and fibroids, epididymitis, gallstone and renal colic, and reflexly with pneumonia and pleurisy.
4. Dynamic Ileus in which the musculature of the bowel wall is contracted, as in lead and some other poisonings,

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and in diseases of the central nervous system.

Ochsner and Gage state that most cases of ileus developing 24 to 48 hours post-operatively are adynamic in type. This type results from peritoneal or splanchnic irritation which may be chemical, thermal or bacterial in nature.

Adynamic ileus is almost always associated with peritonitis. Here as in the mechanical types, intestinal secretion increases, the bowel becomes distended, absorption is lessened and toxemia develops. However, in this type of ileus the pain is dull in character and is continuous. It is not the colicky type of pain found in the early mechanical types.

Auscultation is most important because in the adynamic type, as in peritonitis, there is the silent abdomen with complete absence of all peristaltic sounds, instead of the turbulent, gurgling bowel noises such as one hears in the mechanical types.

In adynamic ileus the paralytic obstruction generally involves the entire intestinal canal. Fey and Cubbins feel that at times only a segment of the bowel may be so affected. It is possible that in some instances of slight involvement this may be true.

In the differential diagnosis it is necessary

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to remember that distention, dilation of the stomach, dehydration due to loss of absorption, and alkalosis, may develop in both types. The passage of flatulence and feces may follow enemas in both types. Chills may be present in the adynamic but not in the mechanical type.

When peritonitis develops there is temperature, constant pain and leucocytosis. It is most important that we differentiate between these two types because in the mechanical form early surgery offers the only help, while in adynamic ileus, with or without peritonitis, stomach and duodenal drainage as advocated by Wangenstein will generally suffice.

According to Orr (17) the direct and indirect causes of adynamic ileus are many. In the absence of direct injury to the abdomen or its contents we must consider extra-abdominal causes as the important factors initiating abdominal distention. These factors may be toxic or neurogenic. In considering abdominal distention associated with fractures, the toxic factor is of secondary importance. The neurogenic factor probably has as its basis a stimulation of the splanchnic nerves which inhibit intestinal activity. The mechanism of such stimulation is conjectural. The inhibitory influence is conducted through the splanchnic nerves to the plexuses

of Meisner and Auerbach in the intestinal wall.

The results of splanchnic inhibition are increased intra-enteric pressure, decreased or absent peristalsis, distention of the gut, decrease in absorption from the lumen, accumulation of secretions in the lumen, accumulation of gas and liquid bowel content in the distended portion and finally an interference with the blood supply to the bowel wall by overdistention and obliteration of the small vessels, particularly at the antimesenteric border. In paralytic or inhibition ileus the disturbed blood supply rarely reaches the stage which results in bowel wall gangrene and perforation. Obstruction or strangulation may cause a necrosis of the mucosa with a decrease in absorption through the mesenteric vessels and permit a transperitoneal absorption of toxic products.

As stated by Ochsner (16) the normal function of the gastrointestinal tract is that of digestion and assimilation, which is accomplished through secretion, peristalsis and absorption. Although the gastro-intestinal tract is supplied by the plexuses of Auerback and Meisner, the secretion and motility are also regulated by extrinsic nerves, the sympathetics and parasympathetics. Bayliss and Starling and MacLeod have shown that although

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peristalsis and secretion will continue in the experimental animal following the removal of all the extrinsic nerves, irritation, stimulation, or inhibition of these nerves does produce changes in intestinal activity, both motor and secretory.

Muller showed that in ileus there is an increased secretion into the gut lumen. Suelberger, Brandes, and Roth, in an extensive experimental investigation, demonstrated that in ileus there was definite decreased absorption from the obstructed gut. This they believe is due to the hypertonicity of the contents of the bowel in ileus and that as the distention increases the vital selective absorbability of the intestinal mucosa is lost and it acts as a diffusion membrane.

Dragstedt, Lang and Millet have shown that there is considerable variation in the intramural blood supply in the various parts of the intestine, and as a result of this anatomical variation, pressures within the gut exert varying influences on the blood supply of the intestinal wall. They found that the flow in the veins of the walls of the intestine ceased when the intra-intestinal pressures within the duodenum, the jejunum, the ileum and the colon attained heights of 35 to 45, 55 to 65, and 95 mm. of mercury, respectitely. This, they believe, is

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due to the variation in the length of the intramural blood vessels. They found that if a cross section of the bowel were represented by the face of a clock with the mesenteric attachment at six o'clock, the vasa recta pierce the muscularis in the case of the duodenum at approximately five and seven o'clock, in the jejunum and the ileum at three and nine o'clock, and in the case of the colon at two and ten o'clock. In the duodenum any increase in intra-intestinal tension exerts considerable pressure on the vessels which lie between the mucosa and the relatively inelastic muscularis. In the colon, however, in which the greater portion of the vessel lies outside the muscularis, an increase in the intra-intestinal pressure exerts relatively little effect on the blood supply. Because the secretion is much more marked in the upper intestinal tract than in the lower as the result of the pouring into it of the duodenal, the pancreatic, and hepatic secretions and also because of the peculiar anatomic arrangements of the duodenal and the jejunal vessels, it is obvious that an obstruction high in the intestinal tract is likely to produce interference with the blood supply and strangulation within the wall of the bowel. This is probably the reason why toxemia in high intestinal obstruction is much more severe than a similar obstruction lower down. Morton and Sullivan

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compared equal sized closed loops of the duodenum and ileum and found considerable differences as regards the amount of secretion and intestinal distention. They found that there is an average secretion into the duodenum of 49 c.c. as compared with .9 c.c. for the ileum. Most of the animals with the duodenal closed loops died from rupture of the duodenum after the end of forty-eight hours. The intra-intestinal pressures were measured and it was found that the pressures within the duodenal segments markedly increased until they were from four to seven times as great as those in the ileum. Burget et al. demonstrated that symptoms in experimental animals with closed loops were dependent upon the distention within the loops. They determined the intra-enteric pressures of subcutaneous loops and found that the animals exhibited no toxic symptoms as long as the intra-intestinal pressures were low. However, as soon as a loop became distended, the animal presented signs of toxicity; i.e., did not appear lively and refused food. On the other hand, when the contents of the loop were aspirated and the intra-intestinal pressure relieved, these symptoms quickly disappeared. If the distention of the loops was allowed to continue, vomiting and apparent depression occurred and a longer time was required for the animal to recover following relief of the pressure within the closed loop.

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How can one, therefore, explain the symptoms and death in those patients with normal blood chemistry and with no evidence of dehydration, particularly after the administration of large amounts of chlorides? Unquestionably, death in intestinal obstruction is the result of the absorption of toxins which probably occurs only when there is an interference with the blood supply to the bowel; viz., strangulation. Numerous attempts have been made to demonstrate toxic substances in the blood stream draining the involved segment. This has been difficult, however, because, although there may be sufficient absorption from obstructed strangulated intestine to cause death in the affected animal, it is impossible to obtain all the blood draining from that area and the relatively slight effect exerted on an otherwise normal animal is not sufficient to cause death. Sugito demonstrated that blood obtained from the superior mesenteric veins in animals with ileus was much more toxic than that obtained from the peripheral circulation. Scholefield found that mesenteric blood from a strangulated loop in a dog produced toxic manifestations when injected into mice. Carlson, Lynch, and Wangenstein performed similar experiments but obtained less marked results in that the blood removed from

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the portal veins of animals with ileus caused only temporary symptoms when injected into other animals.

As the result of extensive physiologic and biochemical investigations, it is evident that in ileus there is considerable disturbance in the normal function of the gastro-intestinal tract.

Whereas the normal function of the gut consists of peristalsis, secretion, and absorption, these activities are so altered in ileus that life of the individual is endangered. Mechanical obstruction to the intestine increases peristaltic activity which is expressed clinically by colicky or cramp-like pains in the abdomen and increased peristaltic sounds.

Adynamic ileus is the result of peritoneal or splanchnic irritation which can be mechanical, chemical, thermal or bacterial. In both types of ileus, mechanical obstruction and the adynamic variety, there occurs increased gastro-intestinal secretion, decreased absorption, and a failure of transportation of the gastric and upper intestinal secretions into the lower bowel, either because of the mechanical blocking or the absence of peristaltic movement. Concomitant with and dependent upon the increased secretion, diminished absorption, and retention are stasis of the secretions and dilatation of the stomach and upper intestine, which, if unrelieved, cause nausea and vomiting.

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The secretion of large quantities of fluid and electrolytes from the stomach, duodenum, pancreas, and liver without subsequent absorption of these substances from the normal absorptive areas of the intestinal tract, the ileum and colon, results in the loss of fluids and electrolytes, particularly chlorides. Although the fluid may remain in the stomach, it is lost to the body, as under such conditions it remains stagnant in the stomach and duodenum. It is far better for the patient that the stomach and the intestine be emptied of this material, because distention causes further secretion. It is for this reason that an indwelling duodenal catheter and active suction, as suggested by Wangenstein, are used.

Matthews (12) says that most of our adynamic ileus is due to the handling of the abdominal contents as well as exposure of the bowel to the air. In all operative cases there is more or less a paralytic ileus from a small degree to a complete and prolonged obstruction, depending upon the trauma, exposures and other causes enumerated above. The mild form may be called a physiologic one following all abdominal operations. While it may last only a few hours and involve only a small portion of the bowel, it should always be expected. Much of this form of ileus can be prevented by the avoidance of purges and stimulative enemata before operation,

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gentle manipulation during operation and avoiding long exposure.

Vomiting persisting after 24 hours should arouse suspicion, especially with a distended abdomen without definite pain, which in adynamic ileus is conspicuously absent. We have no borborygmus, but with the stethoscope one can often hear a metallic-like tinkle, otherwise a silent abdomen. A most valuable adjunct is the X-ray examination, which will show the distended coils of bowel with the typical stepladder-like appearance.

Heiberg (11) states that paralytic ileus is noted most often in the presence of peritonitis. Varying in duration and degree, it is seen following every intra-abdominal operation, but, fortunately, the distention, nausea and vomiting usually subside in eight to twenty-four hours, when the dilated gut begins to contract with the production of gas pains. During the performance of a laparotomy, trauma, exposure of the bowel to air, and packs that are too hot or too cold are frequently factors in producing adynamic ileus. Several writers have noted that worried, apprehensive patients are somewhat prone to develop postoperative ileus. Penetrating abdominal wounds, the extravasation of blood, and mesenteric thrombosis are also etiologic factors.

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Paralytic ileus may be of nervous origin, as the result of injuries and diseases of the spinal cord, or fracture of the lower ribs or lead poisoning. It may be of toxic origin as in pneumonia, uremia, undulant fever, meningitis and empyema. And it may be reflex as noted in renal or gallbladder colic, torsion of an ovarian cyst, crushing of a testis or strangulation of the spermatic cord.

A progressive dilatation of the bowels with a corresponding thinning of all the layers of the intestines is the only pathological change noted in early paralytic ileus. As a result of this distention, intestinal secretion is increased, while the venous stasis diminishes absorption from the bowel, so that large amounts of stagnant toxic fluid collect in the gut. Swallowed air, fermentation and gas-producing organisms also play a part in increasing the distention. At first the bowel is normal in appearance, but the persistent venous stasis, produced by the extreme dilatation, causes it to become progressively lavender, purple, black and gangrenous. The intra-abdominal exudate may be serous, fibrinous or fibrinoplastic.

DIAGNOSIS

Heiberg, (1), states that in paralytic ileus the predominating sign is abdominal destention, which usually involves the entire bowel. The pain, if present, is not intermittent or colicky in character, but is described as being a continuous dull generalized abdominal ache. As the tympanitis increases, the pylorus relaxes, permitting intestinal contents to regurgitate into the stomach, producing nausea and later vomiting. Respirations become rapid and shallow, due to the marked increase of intra-abdominal pressure. The pulse is rapid and thin. The patient appears to be alert and apprehensive at first, but gradually becomes drowsy, cyanotic, and comatose. Delirium often supervenes before death. Peristalsis is relatively or completely inhibited, resulting in a "silent abdomen". A scout film will show a gaseous distention of both the small and large bowel, fluid layers between the coils, fluid mirrors in which air is layered over fluid, and frequently a socalled "ladder pattern" is noted.

Partridge, (19), believes that in diagnosis there is considerable difficulty experienced in differentiating between paralytic or adynamic and mechanical ileus. Adynamic ileus occurs earlier, the first twenty-

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four to forty-eight hours postoperatively, and is characterized by an absence of intermittent colicky pains. Paralytic ileus involves primarily the splanchnic nerves and the entire bowel is involved. Mechanical ileus involves a local sector of bowel and there are the intermittent colic pains. Any hollow viscus, when compressed mechanically and locally, has this characteristic intermittent colicky pain.

Plain X-rays of the abdomen are of much value in diagnosis of any form of ileus. X-ray was first used in 1911. Dilated loops of intestine filled with fluid and gas occurs earlier in mechanical ileus and is more marked where there is interference with the blood supply to the bowel.

It has been suggested that excessive stimulation of splanchnics inhibits peristalsis. Then one would think splanchnic block would be a means of differential diagnosis between mechanical and paralytic ileus. This has been advocated, but investigators have found that experimental splanchnic block in every case produced increased intestinal tone.

The main reason for a differential diagnosis between paralytic and mechanical ileus is the that the

former must be treated very conservatively while the latter should have little delay in surgery.

Eliason and Johnson, (7), state that the term ileus is derived from the Greek meaning "to twist". Bottomly states that "ileus is a term used to designate as a whole that group of symptoms, (colicky pain, constipation or obstipation, distention of the intestine, nausea and vomiting), which indicate the existance of an intestinal obstruction". Most writers, however, use the term "ileus" as synonymous with "intestinal obstruction" and such is our interpretation.

It will be noted that no mention is made of peristaltic action in the above description, and the reason is that its absence or presence depends upon the type of ileus; namely, whether it is paralytic or mechanical. In paralytic, reflex or adynamic ileus, the peristalsis is absent in the affected gut, although it is possible that active peristalsis may exist in the unaffected gut proximal to the obstructed segment. In the mechanical and dynamic types, peristalsis is hyperactive, until late in the course of the disease when, due to overdistention, the gut becomes paralyzed and peristalsis ceases.

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As far back as records exist intestinal obstruction has been attended by a high mortality. Even today records show a disgraceful and appalling death rate; namely, fifty percent. Strangulation types head the list. Many careful analyses have show conclusively that as the duration of the obstruction increases the mortality increases. Richardson has stated that the longer a patient with intestinal obstruction lives before operation, the shorter his life after operation.

It is true that Wangenstein suction has done much to relieve symptoms, and blood chemistry findings have done much to combat lethal chemical changes, with some slight resultant lowering of mortality; yet, the chief factor in reducing mortality has clearly and repeatedly been shown to be early diagnosis. Our knowledge of the physiology of the disease and the cause of death is still scant. It has, therefore, become apparent that if the mortality is to be reduced, in the light of our present knowledge, the diagnosis must be made earlier; that is, in hours rather than days. Thus, it is not without reason that the surgeon has turned for aid to that most renowned diagnostician, the roentgenologist.

Schwartz, in 1911, was probably the first one

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to demonstrate intestinal obstruction with the X-ray. Although, he used barium by mouth, he saw multiple fluid levels even before giving barium. In 1913, Assmann called attention to the distended loops of the small intestine on the roentgenograms in five cases shown at autopsy to have intestinal obstruction. Case, writing in 1915, is accredited with being the first in this country to demonstrate the value of X-ray in the diagnosis of acute intestinal obstruction. In recent years there have been many contributions of both experiemental and clinical nature.

The experimental work has come chiefly from the laboratories of surgical investigators. Oschner found that, after experimental strangulation or simple obstruction, the diagnosis could be made in from one to three hours by X-ray examination which demonstrates gas in the small intestine. Similar findings have been reported by other workers, the time interval varying up to six hours. Wangenstein and his coworkers are certain that accumulations of gas in the small gut indicate a pathologic condition; yet, they point out that by means of the X-ray one cannot differentiate between simple obstruction and that more serious condition, strangulation.

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Zuntz and Tache have shown that normally the gas in the intestine is absorbed by the blood stream and eliminated by the lungs; only about one-tenth is expelled by rectum. Thus it might be expected, as shown by Ochsner, that gas appears earlier in strangulation than in simple obstruction. Yet, as has been pointed out, the two conditions are indistinguishable by X-ray.

The presence of abnormal amounts of gas in abnormal locations is taken as X-ray evidence of ileus. The presence of multiple fluid levels is even more conclusive. When the condition is advanced, the diagnosis may be evident to the roentgenologist. However, at that point the diagnosis is also evident to the surgeon.

In the usual case, a careful consideration of this clinical picture will denote the type of ileus. The differentiation, however, may be surprisingly difficult or impossible at times. If the history and surrounding circumstances of the case do not answer the question of mechanical or paralytic ileus, the decision must be made on the presence or absence of colicky pains and fighting peristalsis. The picture is frequently complicated also by a localized are of "paralytic ileus" which allows gas and liquid to go through, but not at its nor-

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mal rate. As a result, mechanical ileus with fighting peristalsis develops in the proximal intestine.

It is said that 90% of acute obstructions occur in the small gut. It is further well known that small gut obstructions are accompanied by more sudden and severe pain and vomiting and exaggerated peristalsis. Whereas, colonic obstruction advances more slowly and the symptoms are less severe.

The postoperative case with ileus, undoubtedly, presents the greatest problem to the surgeon. When the ileus develops in the first two or three postoperative days and the abdomen is silent, it is almost certain to be adynamic or paralytic ileus. If it develops after the fifth day, it is more apt to be mechanical. But as yet we have found no satisfactory way of determining with certainty whether there is an actual mechanical obstruction or whether there is a local paralysis which has produced a mechanical type of ileus in the proximal intestine. Nevertheless, the surgeon is in a better position than the roentgenologist to make the differential diagnosis.

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Several workers have accomplished small intestinal intubation in man; McClendon and his associates (13), in 1920, reported on the hydrogen ion concentration of the contents aspirated from two subjects, but their technic required four days for the tube to reach a level almost four or five feet below the pylorus, none of their methods has led to extensive investigation or important results. Recently, however, we have developed a technic that seems practical, and that, we believe, may eventually be applied in a more or less routine fashion.

According to Miller and Abbott (14), the small bowel excepting the duodenum has been less extensively and less satisfactorily studied than any other unit of the gastrointestinal system. Various explanations readily suggest themselves: its inaccessibility for direct investigation; the complexity and varied sources of its secretions; the difficulty of obtaining its contents, even in experimental animals, in a normal state of the organ, its elusiveness under the roentgen-ray; its relative immunity from disease. Our knowledge of its secretory and motor functions has rested almost entirely on animal experimentation, on chance observations at operation and on the study of the contents obtained after jejunostomies and ileostomies, methods which have lead to invaluable results.

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Miller and Abbott state that the desirability of intubation of the human small bowel beyond the duodenum for the study of intestinal physiology as well as for diagnostic and therapeutic purposes has been appreciated since the introduction of stomach and duodenal tubes. Isolated descriptions of its accomplishment have appeared from time to time, but none of the methods has proved practical, chiefly because of the time required for passage of the apparatus into the bowel and because the tubes employed have been too small to permit ready extraction of the jejunal or ileal contents. The apparatus which we have developed and the technique for its use which we will describe not only overcome these two objections, allowing ready passage throughout the jejunum, often into the ileum, and supplying an adequate lumen for the extraction of intestinal contents, but also permit simultaneous kymographic records of pressure changes within two areas of the upper half of the digestive tract or the injection of substances directly into the stomach, duodenum or the small bowel at any desired point above the termination of the tube. Furthermore, its introduction is little more disturbing to the subject than the passage of an ordinary duodenal tube, and it is easily and quickly removable by the mouth. (15)

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Scheltema (20), in 1908, gave the first description of successful intubation, referring to it as permeation or sounding of the gastro-intestinal tract. In animals he was able to pass a small rubber tube through the entire tract, removing it per rectum, and finally accomplished intestinal intubation in a few children, using a tube of 3.8 mm. diameter with a bulbous distal extremity. He referred to its possibilities for the introduction of medicinal substances in cases of intestinal parasites and cholera infantum, but apparently did not consider the aspiration of contents practicable. His tube was introduced by the nose and required several days to reach the small bowell.

In 1919, Einhorn (4) (5), unaware at the time of Scheltema's experiments, described the use of a soft rubber tube, 8 mm. in circumference, with an attached perforated capsule, for the injection of fluids into the intestinal tract. It, also, required much time to reach the small bowel and was too small to permit aspiration of the contents. Buckstein, in 1920, referred to the use of an intestinal tube for the injection of a barium mixture in order to study loops of the small bowel by the Roentgen ray. He was able to pass his tube 120 to 140 cm. beyond the teeth, and suggested its use for the study of the physiology and bacteriology of the small

intestine. Einhorn, during the following year, described a jointed tube, made up of sections of one meter lengths, which he claimed permitted aspiration at one and sometimes two meter depths, but it was too small for extractions at lower levels. No studies on aspirated specimens were reported. In order to get this tube into the jejunum and ileum, repeated feedings and much time were required. A single case was referred to, the tube reaching the cecum on the third day; at that point it was employed for the instillation of medicated fluids as treatment for an ulcerative colitis; it was finally evacuated per rectum. Later, in 1923, he reported its use in two other cases of ulcerative colitis--in these it required six days for the tube to reach the cecum.

Apparatus

The apparatus which we have developed has grown out of a considerable personal experience with various types used for experimental and clinical studies on the duodenum and small bowel. Its special virtues lie in the fact that it has at its distal end a collapsible rubber bag, which, when distended, may be grasped by the peristallic waves and carried along relatively rapidly in the intestine, and in the fact that the tube

two lumina, one of which is used for inflation and deflation of the rubber bag while the other remains free for extraction and injection purposes.

Before securing a double-lumened rubber tube, we experimented with two separate tubes, one within the other, this arrangement giving theoretically all the advantages of the present apparatus, but often the space between the walls of the two tubes, used for aspiration purposes, became occluded; also, the inner tube had too small a lumen to permit satisfactory kymographic records. It served, however, to demonstrate the practicability of our proposition for a double-lumened tube.

Much difficulty was encountered in having a double-lumened tube of sufficient length manufactured. About fifty of the more important producers of medical and special rubber goods in this country were visited or written to, but only one thought it possible to make such a tube and was willing to undertake some experiments. The U. S. Rubber Products Company of New York City was finally able to supply us with the tube. It has an outside diameter of 6 mm. Its walls and the partition are of 1 mm. thickness; the two lumina are of equal size, each a little larger than that of the ordinary duodenal tube. It is reasonably flexible, does not kink on sharp bending and has a fairly smooth external surface.

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Technique

The technique of intubation, as we have practiced it, is simple. The tube with the bag deflated is taken by the fasting subject in the early morning, exactly as are gastric and duodenal tubes, only enough being swallowed at first to reach the stomach, and then with the subject reclining on his right side, more is introduced slowly until the distal end has reached the duodenum. Entrance into the duodenum may be determined by the character of the contents obtainable from lumen B, or preferably by fluoroscopic observation. The special posture is no longer required but a little more tube is taken and fluoroscopic observations are made until the capsule has reached at least the third portion of the duodenum. Then the bag is distended moderately with air or an 8% sodium iodid solution (to render visualization of the tube and bag easier). After this the subject swallows about 5 cm. of tube every 10 minutes, fluoroscopic observations being made from time to time until the distal end has reached the desired point.

We have found that within six hours the tube has usually passed along the bowel to a distance of 120 to 150 cm. beyond the pylorus. According to Einhorn the length of tubing required to reach from the pylorus to the cecum in the living human is approximately 270 cm.: this suggests that our tube usually reaches the half way

point in the small bowel within six hours. In confirmation of this is the fact that fluoroscopic observation of a barium solution injected at the termination of a tube passed 120 to 150 cm. beyond the pylorus does not usually show evidence of valvulae conniventes, which are present only in the upper two-fifths of the small bowel, the jejunum; this indicating that the ileum has been reached.

Thus, without the necessity of having the subject take any food and within the early half of the day, the apparatus can be introduced into the upper ileum. Beyond this point it does not go so rapidly, probably because of the slight rigidity of the tube, but we anticipate that with an improved type of tubing even deeper penetration may be secured within the same period of time.

Once in the position desired the apparatus may be used for various purposes: with the bag inflated moderately and lumen A connected with a recording apparatus, continuous kymographic records of pressure changes may be secured; if the apparatus is equipped with two bags, simultaneous records from two areas may be obtained; when the bag is deflated, and the other lumen B communicates with the interior of the bowel, aspirations may be made or substances may be injected at a fixed point.

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It is not our purpose to refer to special studies made with this technique in this communication, but we may say that certain investigations of the chemistry and physiology of the small bowel are under way; also studies on the motor effects upon the bowel of drugs administrated orally, by lumen B of the tube, and by hypodermic injection. Shiffer, of our section, using a modification of the apparatus, has perfected a technique for obturation of the lower duodenum and retrograde filling of that organ with an opaque substance which provides a satisfactory method for differentiating by the Roentgen ray certain obscure duodenal lesions. Bacteriologic study of the contents of the small bowel under fasting conditions and after the administration of certain types of food, also investigation of the anatomical relationships of the coils of the jejunum, are planned. It is believed that this apparatus and the technique described furnish a direct means of studying many problems in the human that could not be attacked satisfactorily before.

Conclusions

1. A new apparatus, involving the use of a newly developed double-lumened rubber tube, for intubation

of the human small intestine, and the technique for its employment are described.

2. By means of a rubber bag, attached at the distal extremity of the tube over an Einhorn or Rehfuss duodenal bulb and distended when it enters the lower part of the duodenum, the apparatus is pulled along the intestinal tract by peristaltic waves.

3. As now developed, the distal part of the apparatus will usually reach the upper ileum within about six hours, and it is believed that further developments may lead to even deeper penetration within the bowel.

4. The apparatus may be used to secure intestinal contents from, or to inject substances into, any area within the upper half of the intestinal tract or to secure records of pressure changes from a fixed point of the tract or simultaneous records from two areas. It may lead eventually to new methods of diagnosing and treating intestinal lesions.

Wangenstein (24) states that in inhibitive (paralytic) ileus where the colon is also distended, it is well to employ a rectal catheter as well as an inlying nasal tube led into the stomach and upper reaches of the small intestine. Because of the usual presence of feces in the large bowel, it is best to employ irrigation

alternating with suction, using a small inflow and a large outflow tube. Scott (21) has employed a special duodenal tube at the University Hospital for the past two years, which appears to enter the duodenum more readily than the Levine tube. The distal five inches is more heavily impregnated with lead than the rest of the catheter and in consequence it follows the gastric pathway along the lesser curvature of the stomach and is less inclined to curl up in the stomach. After the tube is passed into the stomach, suction is applied and the stomach is evacuated. When emptied, suction is temporarily discontinued, the patient is turned on his right side, given sips of water to drink over an interval of about twenty minutes, the catheter being meanwhile gradually advanced. In the majority of instances even in the presence of considerable distention the catheter then finds its way into the duodenum. Suction is now again resumed. Occasionally the tube fails to enter the duodenum, but failures with this tube have been less frequent than with the ordinary duodenal tube. The tube has perforations extending proximally for about ten inches, such that simultaneous suction may be expressed upon both the stomach and the upper reaches of the small intestine.

The technique of nasal catheter suction siphonage has been described in detail elsewhere and will

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not be related at length here. An obvious essential is the liberal administration of paraoral fluids. Enough fluid should be given to insure a liberal urine output. The excretion of 800 to 1000 c.c. of urine every twenty-four hours affords as reliable an indication of a positive tissue fluid balance as do more elaborate chemical tests. Five per cent glucose in saline solution given slowly intravenously (3000 to 5000 c.c. daily the amount being contingent on the urine output) or subcutaneously serves to combat the dehydration incident to accumulation of fluid in the intestine and its removal by suction.

The duodenal tube has become an important agent in the equipment of the physician who diagnoses and treats abdominal ills.

It is more than twenty years since the duodenal tube was first employed in the relief of postoperative distention. At the University Hospital, we have found the employment of the duodenal tube, with suction, efficacious in the control of postoperative nausea, vomiting and distension as well as in the treatment of reflex and inhibitive (paralytic) types of ileus and in certain types of acute mechanical intestinal obstruction.

Our impressions of the value of nasal cathe-

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ter suction siphonage in the treatment of mechanical types of obstruction, and in the treatment as well as the prevention of postoperative distention, nausea and vomiting have been published elsewhere. The method has been employed on more than 400 patients on the surgical service at the University Hospital. After operations upon the stomach, gallbladder or bile ducts, in which postoperative distention is frequent, nasal catheter suction siphonage is routinely employed. A recent check of the hospital records shows that the incidence of vomiting, in instances of peritonitis, has been reduced from 90 to 15 per cent through the employment of suction with the duodenal tube, emphasizing the significance of stasis in the gastro-intestinal canal in the genesis of the vomiting of peritonitis. The apparatus consists of the following articles:

1. Two large glass bottles, graduated and holding 4000 c.c.
2. A two-hole rubber stopper which fits one of the bottles snugly.
3. A Levine duodenal tube with the perforations continued up from the tip 9 or 10 inches.
4. A canvas sling to hold one of the bottles inverted.
5. An irrigation standard.

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6. About 8 feet of ¼ inch rubber tubing.
7. Two ¼ inch glass tubes, 4 and 14 inches long.
8. A screw clamp.

The canvas sling is fitted over one of the bottles and this bottle is filled with water. The glass tubes are so placed in the rubber stopper that the longer glass tube will extend almost to the bottom of the bottle and the shorter glass tube will extend just through the stopper into the bottle. The rubber stopper is then fastened securely in place as indicated in the diagram.

The top bottle is hung inverted from the irrigation standard at a height of 5 to 6 feet. The thumb is placed over the free end of the rubber tubing attached to the longer glass tube and the screw clamp loosened. If suction is perceived immediately, the apparatus is ready for use.

With a little care a Levine duodenal tube can be passed through the nose and into the stomach without causing the patient to gag, choke or retch. Patients should be instructed, however, to breathe rapidly through their mouths if they experience any tendency to do any of these.

The duodenal tube should be lubricated with mineral oil or glycerine and the tip inserted through one of the nares into the posterior nasopharynx, but

not far enough to cause the patient to gag. The patient is then asked to take a mouthful of water and hold it in his mouth. The patient is instructed to swallow slowly and as he swallows, the tube is slowly inserted.

When the tube has been inserted and adjusted it is fastened to the patient's upper lip and cheek with adhesive tape, and connected with the suction set. When the clamp is unscrewed the apparatus is in action. The apparatus works on the principle that water tending to run from the top bottle to the bottom bottle creates a vacuum in the top bottle which is transmitted through the long glass tube and hence to the duodenal tube. Therefore, if water runs out of the top bottle an equal volume of gas or fluid must run in. To measure these quantities is quite easy and very important for maintaining the patient in a positive fluid balance.

The fluid balance is maintained meanwhile by the subcutaneous and intravenous administration of fluids. The urine output is a good criterion of how much fluid should be given and we have found it to be a very practical and reliable estimate of the fluid balance. If the daily urine output is maintained at 700 to 1000 c.c. one may feel certain that the blood chlorides are normal. It is usually necessary to give 2500-4000 c.c. of fluid by the para-oral methods to

insure this urinary output.

After the suction has been operating successfully for twenty-four hours or more in postoperative patients, it may be interrupted intermittently by clamping one of the tubes. Not infrequently patients will complain of distress when the tube is clamped and beg to have it released or will unclasp it themselves. When the patient can tolerate interruption of suction for an hour or more without complaint, he may be permitted clear fluid by mouth.

Einhorn (6) reports the case of Dr. Alexander S., twenty-six years old, became sick twenty-four hours after a hypodermic injection in the right shoulder. There was a swelling of the upper arm, and rise of temperature with chills. He was treated in the hospital for five months for a severe form of general septicemia, requiring a number of operations for the opening of abscesses situated in different regions of the body. He was in such a critical condition that blood transfusions had to be performed at frequent intervals. His temperature fluctuated between 101 degrees and 104 degrees for about four months. Then it began to go down to 99 degrees. At this period the patient suddenly began to vomit and suffered greatly from distention of the abdomen.

At this time there was persistent nausea with occasional vomiting of large quantities of fluid, freq-

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uently bile colored. Distention of the abdomen with contractions of the stomach were observed by the physician in charge. Extreme weakness, anorexia, and sleeplessness had been continuous for the last three days. A diagnosis of acute dilatation of the stomach with ileus of the upper portion of the small intestine was made. The treatment instituted was gastric lavage, atropine and intravenous injections of saline and glucose. The duodenal tube was then given and feeding of barley water through tube commenced, also washing of the stomach twice daily. At first large quantities of bile colored fluid were siphoned out in the fasting condition. A day or two later the return flow from the tube began to be diminished in the fasting condition, and also half an hour before the last feeding. Thus on April 19th the return flow from the tube in the fasting condition was light green. Murphy drip of 500 c.c. of saline and glucose was given, first per rectum, later on through the duodenum. Feeding of four ounces of milk through tube was commenced on April 21st. On the next day the patient felt uncomfortable and had contractions of the stomach. On April 23rd a soapsuds enema had good results; the stool was light brown in color. Feedings through the tube with milk, lactose and egg

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were begun. Examination of the duodenal contents showed that the tube had entered the duodenum. An X-ray of the abdomen was taken while the patient was in bed and showed the end of the tube far into the jejunum.

From then on the feedings were increased and all additional fluids given by the drip through the duodenum. The duodenal alimentation went on very well. At the end of April, in addition to the duodenal feedings, some food was given by mouth. The patient felt quite comfortable and picked up in strength. On May 5, 1935, the tube was withdrawn and regular meals were given by mouth. The patient rallied quickly and left the hospital on June 5, 1935.

Introduce a duodenal tube into the stomach. Use it first for washing the stomach and siphoning it, whenever the patient complains of fullness and distention. Give fluids, glucose solutions, barley water, also diluted milk in small portions through the tube and watch results. Whenever the patient feels very uncomfortable, siphoning out of the contents must be done, to be followed by washing of the stomach with a small amount of fluid - two or three ounces. The tube meanwhile is given a chance to move into the digestive tract. In order to help this process atropine is given twice daily, if necessary 1/120 or 1/100 of grain.

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As soon as the capsule end of the tube has entered the duodenum or has reached the beginning of the jejunum, regular duodenal feedings of milk, raw eggs, and one to two pints of 5 to 6 percent glucose solutions by drip through the tube twice daily. After the patient is getting along nicely, you can begin with additional food by mouth, at first once a day, later twice daily. After two or three weeks the duodenal tube may be removed and regular feeding by mouth given. The diet is then quickly enlarged, so that the patient within a week or two can eat ordinary foods with his family. Even feeding between meals is good to make them gain weight and bring them back to normal.

As stated by Heiberg (11) prophylactic treatment is extremely important in adynamic ileus. Preoperative care includes mental preparation of patient, because a "nervous," worried patient is more susceptible to stimulation of the sympathetics, with a resultant inhibition of peristalsis. Therefore the fears and apprehension of all such patients should be allayed as much as possible.

Cathartics should not be given before surgery. Alvarez has shown that, following purgation, there follows a period of inhibition of peristalsis. In the

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operating room prophylaxis is very important. The intestines must be handled very gently, they should be exposed to the air as little as possible, and blunt dissection should be avoided. Proper temperature of all moist laparotomy packs must be maintained, and careful hemostasis must be obtained, because free blood in the abdominal cavity acts as a peritoneal irritant. Soresi and Brown, among others, advise dilating the anal sphincter before the patient leaves the operating room, to permit gas to escape freely from the rectum.

Postoperatively, all liquids by mouth should be withheld until nausea and vomiting have subsided. A common practice is the routine application of heat to the abdomen, by stupes or the use of a cradle equipped with electric bulbs, or short wave diathermy, until signs of ileus have subsided.

After establishing a diagnosis, morphine is a very useful drug, and may be used freely in paralytic ileus. We formerly believed that morphine "splinted" the bowel, but recent studies have definitely demonstrated that it increases its tone. Ochsner states, "morphine should be administered liberally after operation (in the case of an adult, unless some contraindication exists, the patient should receive ¼ grain of morphine sulphate every four hours whether they complain of pain or not),

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because, as has been shown repeatedly both in the laboratory and the clinic, morphine increases the intestinal tone and does not inhibit the gut as is commonly thought." If these preventive measures are unsuccessful, and the paralytic ileus develops, prompt and energetic treatment is necessary.

1. To combat the dehydration, starvation and hypochloremia, saline and glucose solutions must be given intravenously. Hypertonic salt solutions are very useful not only to replace the chlorides that are lost, but also to stimulate peristalsis. Wangenstein states that "1/6 to 1/3 grain per kilo body weight may be safely injected, 75 to 100 c.c. of a 15 per cent solution of sodium chloride is the usual dose for a person weighing 150 pounds."

Glucose solutions may also be given, by hypodermoclysis or intravenously. Ochsner and Gage report that they have demonstrated that glucose intravenously inhibits peristalsis, but this effect is lost when sufficient insulin is given to "cover" the full amount of dextrose administered. Sufficient fluids should be given to maintain a daily urinary output of 700 to 1000 c.c.

2. Different drugs, used to stimulate intest-

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inal activity have been used with variable results. Chief among these are physostigmin, prostigmin, pitressin, choline and acetylcholine. Physostigmin produces powerful contractions of the smooth muscle of the intestines, probably by stimulating the vagus. It must be used with considerable caution, however, because larger doses than 1/30 grains hypodermically may produce central vasomotor paralysis, cardiac depression, dyspnea, myosis, drop in blood pressure and tetanic contraction of the gut. Because of these undesirable side-effects, physostigmin has been supplanted to a great extent during the past few years by prostigmin, which is a white crystalline powder that forms a very stable solution. It is obtained in two concentrations -- a 1:4000 solution for prophylaxis, and a 1:2000 solution for treatment. The prophylactic dose is 1 c.c. of 1:4000 solution every six hours starting the day before surgery and continuing until the second or third postoperative day. The treatment dose is 1 c.c. of 1:2000 solution, repeated as necessary. Beck, in a report of 220 cases, reports that prostigmin has a marked effect upon the intestine without affecting the heart.

Pitressin, which contains the pressor substance of the posterior lobe of the pituitary body often gives satisfactory results in relieving intestinal distension.

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It is administered in 1 c.c. doses, repeated as indicated.

Choline and its derivative, acetylcholine, occur in animal and vegetable tissues and in some drugs, especially ergot. Their effect upon the intestine is similar to eserin. Canney reports a cure in 75 percent of his cases of postoperative ileus by the use of choline chloride. Abel advises intramuscular injections of acetylcholine in .1 gm. doses every two or three hours until gas is expelled.

3. Enterostomy. Until Wangenstein demonstrated the splendid results that can be obtained by the use of the indwelling nasal suction catheter, enterostomy was generally considered the mainstay in the treatment of paralytic ileus. While this surgical method of draining the intestine has often been a life-saving measure,it is, as Wangenstein point out "only of very limited value because only a short segment of the bowel on either side of the enterostomy catheter is evacuated by the tube." For this reason several surgeons have, in thepast, advised performing multiple enterostomies. The present day concept of the comparative value of these two methods of intestinal drainage, is, I believe, aptly put by Jackson when he states "that in a general way an enterostomy is indicated in all cases of adynamic ileus requiring intestinal drainage, where for any reason nasal catheter suc-

tion cannot be employed, or results cannot be obtained by its use." In other words, the nasal suction apparatus has supplanted the enterostomy as a method of choice in draining the bowel in cases of paralytic ileus.

4. Spinal anesthesia. The splanchnic or sympathetic nerves, which act as inhibitors of the intestines, are blocked by spinal anesthesia. By shunting out the influence of the sympathetics, the motor nerves are unopposed and active peristalsis results. Since in paralytic ileus there is an overactivity of the sympathetic nervous system, it is highly desirable to block out its influence on the bowel. For this reason, spinal anesthesia is widely used in this type of ileus. Splanchnic analgesia is employed by some men, but, according to Brown, the technic is more difficult and likewise more dangerous. He advises using three-fifths the spinal anesthesia dose because that amount of anesthetic does not produce a great fall in blood pressure and is fairly safe when given below the first lumbar vertebra. It should be added that in combating this drop in blood pressure adrenalin or ephedrine should not be given because they stimulate the sympathetics and thus have a tendency to neutralize or offset the effect of spinal block. Therefore, intravenous saline or glucose should be given to counteract the fall in blood pressure.

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5. Decompression by nasal suction catheter. In reviewing the literature on ileus of the past seven or eight years, it is interesting to note the influence that Wangenstein has exerted in the treatment of this condition in advocating the use of the inlying duodenal tube. When his first papers appeared describing this form of therapy, contemporary writers were discussing the merits of single and multiple enterostomies, ileocolostomies, gastric lavage and various drugs. Since that time the use of the nasal suction apparatus as the method of choice in treating paralytic ileus has, in general, superceded all other forms of therapy. The value of its use in competent hands can best be pointed out by citing the experience of Wangenstein, who states that since 1931 when suction first began to be widely employed at the University of Minnesota Hospitals in the treatment of distention, no patient with paralytic ileus has been subjected to operation for its relief. The long double-lumened, balloon-tipped intubation tube, developed by Miller and Abbott in 1934, is a further advancement in the treatment of ileus by decompression. By means of this tube it is possible to decompress the entire small bowell.

Harger and Wilkey (10) used prostigmine (1:4000

solution) over a period of three months at the Cook County Hospital in 175 cases of abdominal operations. The conditions necessitating surgery were varied. In addition to the use of prostigmine in surgical cases, we have also applied it in uremia with associated paralytic ileus with gratifying results, and in one case of obstructive jaundice with coronary heart disease. In this instance a slight rise in blood pressure was noted, which rise, however, aided materially in the prognosis. We have found in prostigmine a very satisfactory method of controlling postoperative distention. No signs of drug intoxication were seen, nor were by-effects on the eye observed. There was no obvious evidence of hyperperistalsis and no complaints of excessive cramps. No adjuvant measures, such as enemas, stupes, heat cradle and the like, were used to enhance the action of prostigmine. The 1:4000 solution of prostigmine methyl sulfate, administered subcutaneously, was used in all cases. If possible, prostigmine medication was started preoperatively.

Comment

Prostigmine has a wide margin of safety. Although intervals between doses of from four to six hours are recommended, and but one ampule per dose, we have con-

stantly given the drug at two hour intervals to patients ranging in age from 14 to 68 years with no demonstrable ill effects. Reports hitherto have recommended longer intervals than two hours. Our results convince us that prostigmine may be given more frequently and in larger doses with assurance of a satisfactory response and no danger of untoward by-effects.

Prostigmine was used in 175 cases. Prostigmine, a 1:4000 solution of the dimethylcarbamic ester of beta hydroxyphenyl-ammonium methyl-sulfate, is a satisfactory agent for the prevention or treatment of distention and paralytic ileus. In our series of cases, the administration of prostigmine was followed by excellent results with a low incidence of by-effects.

Uzmanski (22) states that paralytic ileus is always a grave condition whether the distention is moderate or extreme, or whether it affects part or all of the intestinal tract. It is a disconcerting factor which many times must be met by the most careful of surgeons - operators who make every effort to handle the tissues as little and as delicately as possible, and to apply the minimum of pressure on the bowels when using packs. During the years in which abdominal surgery has become a major specialty various therapeutic agents have

been suggested to treat and to abort this condition.

The alkaloid of physostigmine, eserine, is of value when such a condition follows in the wake of abdominal section or labor. Unfortunately, however, its use here is attended too often by such unpleasant by-effects as slowing of the heart, dyspnea, depression of respiration, bronchospasm.

Studies by Aeschlimann and Reinert result in the synthesis of the dimethyl-carbamic ester of beta-hydroxy-phenyl-trimethyl-ammonium methyl-sulphate, a compound resembling eserine in many of its characteristics. It has been demonstrated pharmacologically that the new substance differs from eserine principally by a more pronounced action upon peristalsis, while its effects upon miosis is of little moment, and cardiac by-effects are practically non-existant.

Bardenheuer uses prostigmin for the relief of postoperative intestinal atony and also as an effective treatment in chronic obstipation. Beck reports the use of the drug in 220 cases. He found prostigmine to have a marked effect upon the intestine but to be without influence on the heart. In some cases he uses the drug every second day as a prophylactic and to maintain peristalsis.

Prostigmine is a new synthetic substance

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recommended as a prophylaxis against paralytic ileus, as a treatment for the established condition, and in cases of bladder atony. It is available in two concentrations, ampules delivering 1 c.c. of a 1:4000 solution for prophylaxis, and ampules delivering 1 c.c. of a 1:2000 solution for treatment.

Partridge (19) states that the plan of essential treatment will vary somewhat according to whether there is mechanical or paralytic ileus. In peritonitis there may be both types. There may be moderate or severe types of paralytic ileus. Nothing by mouth is the rule until all nausea has ceased. It is advocated by some that even proctoclysis should not be given. Application of heat to the abdomen and use of stupes has a logical basis since heat increases peripheral circulation thus decreasing splanchnic blood supply which in turn favors peristalsis and decreases intestinal secretion. Morphine has been shown by a number of workers to help prevent paralytic ileus and it should be used freely.

Intravenous normal or better physiological salt solutions have been shown to increase intestinal activity by ninety per cent. If glucose is given where indicated one unit of insulin for each two grams of glucose should

be given to help metabolize to sugar. It has been shown that when glucose alone is given intravenously there is an inhibiting effect on the bowel which does not occur when insulin is given. Pituitrin seems to be condemned by almost all writers. Pituitrin probably acts on the muscle cells in the walls of the colon and since adynamic ileus involves chiefly the ileum it would seem to be of no help. However, some English authors seem to think it of value. Splanchnic and spinal anesthesia in the hands of most is of no value. In regard to spinal anesthesia it has been explained that the effect in paralytic ileus is due to blocking of splanchnic inhibitory reflexes and allows the vagus motor reflexes to have full play.

Erdman (8) states that high enterostomy for the ileus complicating acute appendicitis with diffus e peritonitis is, today, distinctly on the defensive for several reasons:

First: because there is a well-founded reaction following a period of overenthusiastic country-wide trial of this method, too often employed as a desperate last-resort measure in moribund patients. A chief criticism is that the mortality rate is prohibitively high. But the mortality rate must be evaluated solely in its relation to the high expectant mortality (80%)

of the gravely serious group of cases, in whom enterostomy should properly be employed. It is probably true today that in the larger hospitals many of the pneumonia patients who die, do so in an oxygen tent; but that fact should not be an argument against the use of the oxygen tent. And so with enterostomy, it cannot be justly condemned because so many patients go on to die of their disease despite its use; but the important consideration concerns those lives which have been apparently saved by this method.

Secondly: It is now claimed by enthusiasts that the continuous drainage of the stomach or duodenum by a Levine tube, either without suction, or with suction as described by Wangenstein, is almost a panacea for ileus, and that enterostomy can accomplish no more than suction.

Most recently the Miller-Abbott double lumen tube promises to go much further, in the relief of distention, and may help solve the ileus problem. However, these methods are still in the trial stage. The comfort of the patient with tube drainage is inestimably increased and strength conserved by relief from the nervous and physical effort of vomiting, and by the ability to take water by mouth. However, in practice, continuous suction

of gastric and duodenal secretions may prove quite deleterious to body chemistry, and is probably more of a drain on body fluids than is an enterostomy.

Furthermore, in my experience with peritonitic ileus, it seldom relieves the intestinal distention; and lastly but most important, the deceptive improvement in the patient's subjective symptoms is such as to mask the real pathology, and lead to procrastination on the part of the surgeon, until the opportune time for intervention has forever passed.

The actual cause of fecaloid vomiting in peritonitic ileus and obstruction cases seems to be due to the pressure of gases, generated in the loops nearest the obstruction, arresting and indeed forcing back the oncoming and rapidly accumulating fluid secretions of the stomach, liver, and pancreas until they overflow at the top and are regurgitated from the stomach. "Reverse peristalsis" is commonly spoken of as the cause of such vomiting, and fluorscopic observation of the stomach and the duodenum does show a forward and backward motion; but that the entire or a great part of the small intestine actually reverses the current is not consistent with the clinical symptoms of mechanical obstruction in which the colicky pains accompany the often visible and audible

hyperperistalsis in its ineffectual effort to push past the obstruction. Or, if vomiting is due to late peritonitic ileus, it is generally claimed that by this time the bowel is so paralyzed that its peristalsis ceases which would apply equally to "reverse peristalsis" and to forward motility.

The surgeons who favor enterostomy are agreed that its field is a limited one; that it is not a panacea, that it has been too often imprpperly used, either in moribund cases or too early and therefore possibly needlessly.

Furthermore little can be expected from enterostomy in cases of general peritonitis lacking the element of mechanical obstruction. No surgeon can infallibly differentiate between the symptoms of ileus due solely to the paralytic effect of peritonitis and those other cases in which there is added the element of intestinal obstruction, due either to the kinking of a loop of small intestine, usually in the pelvis, or to mere paralysis of a loop of ileum in the "pelvic stage" of an upward spreading peritonitis.

Haggard calls attention to "the important part played by intestinal obstruction in so-called general peritonitis, particularly postoperative . . . . Here enterostomy is of great benefit."

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In my own experience as witness at postmortems in appendix cases which have presumably died of general peritonitis, actual kinking obstructions may frequently be demonstrated if the pelvic adhesions are not disturbed until they are visualized; then one wonders whether an enterostomy might have relieved the condition.

In 1934 Quain classifies 1000 cases of appendicitis according to extent of peritoneal infection and remarks "enterostomy was performed more often than in the earlier series .. sometimes disappointing, more often generally satisfactory and in many cases evidently life-saving."

If used in cases of fulminating peritonitis with paralytic ileus lacking a mechanical element the results are apt to be most disappointing.

From an analysis of our 42 cases, we can deduce that 8 cases were treated as "last resort" cases, because they died within twenty-four hours. Further, we believe that a considerable number of days, from the incipiency of an attack of appendicitis is requisite before the adhesions of a spreading peritonitis become firm enough to add the mechanical element of a kinking obstruction. Roughly this may be considered six or seven days, counted from the onset of the attack, not of course from the day of operation, which is so variable.

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This means that an enterostomy performed within the first five days from onset may either be unnecessary or else the condition is one of progressive peritonitis without mechanical ileus, and therefore enterostomy will be of little or no value. In our series the mortality was 75 per cent in the 20 cases operated before 6 days, but only 42 percent in the later cases. The greatest field of usefulness for high enterostomy in appendiceal ileus therefore seems to lie in a realm of unrelieved ileus which has the probability of a coexistent mechanical factor.

Looking ahead into the future, one may hope that the Miller-Abbott method of decompressing the entire small intestine will render enterostomies unnecessary, but up to date (1939) I can find very few cases reported of its use in the ileus of spreading peritonitis from appendicitis.

Abbott and Johnston would seem to have effectually disposed of the "reverse peristalsis" theory and to offer the correct explanation as to why the tube can advance in the presence of "mechanical occlusion or paralytic ileus."

"As the gas and fluid are sucked out of the gut, the intestinal walls contract and regaining their

normal propulsive movement, they force the balloon ahead."

Finally, we believe that enterostomy in selected cases still has a field in saving lives.

According to Van Bueren (23):

1) Within a period of 20 years the average mortality of acute ileus cases operated upon at the Presbyterian Hospital, New York, has been reduced from 66.6 per cent (1916 to 1919) to 28.4 per cent (1932 to 1935).

2) This reduction in mortality percentage has been gradual and regularly progressive (as compared by four year periods) with the exception of one period, following the hospitals removal to a new district, when the cases were received later than usual.

3) The improvement applies to the cases upon whom an enterostomy was effected as well as to those upon whom it was done, but the reduction in mortality was much greater in the non-enterostomy group than in the enterostomy group. This discrepancy appears to be in part due to the fact that, in general, the non-enterostomy group were operated upon earlier than the enterostomy group.

4) The three factors chiefly responsible for this reduction in mortality percentage appear to be:

a) Earlier diagnosis and operation.

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b) A clearer conception of the problem to be solved by treatment.

c) More intelligent handling and management of the cases.

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