5-1-1938

Postoperative paralytic ileus: its mechanism and treatment

A. E. Raitt
University of Nebraska Medical Center

Let us know how access to this document benefits you
http://unmc.libwizard.com/DCFeedback

Follow this and additional works at: https://digitalcommons.unmc.edu/mdtheses
Part of the Medical Education Commons

Recommended Citation
https://digitalcommons.unmc.edu/mdtheses/695

This Thesis is brought to you for free and open access by the Special Collections at DigitalCommons@UNMC. It has been accepted for inclusion in MD Theses by an authorized administrator of DigitalCommons@UNMC. For more information, please contact digitalcommons@unmc.edu.
POSTOPERATIVE PARALYTIC ILEUS
ITS MECHANISM AND TREATMENT

SENIOR THESIS
A. E. RAITT
***

PRESENTED TO THE
COLLEGE OF MEDICINE
UNIVERSITY OF NEBRASKA
OMAHA, 1938
TABLE OF CONTENTS

Introduction................................. 1

Anatomical and Physiological Consideration.... 4

Mechanism of Postoperative Paralytic Ilius....14

Pathology........................................ 27

Pathological Physiology........................29

Diagnosis........................................ 33

Treatment........................................ 35
INTRODUCTION

Lawrence Abel(1) introduced the subject of postoperative paralytic ileus when he wrote: "The manner in which a patient's intestinal peristalsis will be affected after an abdominal operation is one of the most important of the unknown factors which materially affect not only the comfort but sometimes the life of the patient."

It is the purpose of this thesis to present a survey of the literature on the problem of postoperative paralytic ileus. By paralytic ileus we mean that there is no mechanical hindrance to the passage of the fecal stream, but as a result of interference with the nerve supply to the gut or of changes in the gut wall itself, the normal intestinal movement is inhibited. Various terms have been used to denote such a condition. Nothenagle(2) described such a condition which he labeled "ileus paralyticus," others such as "adynamic ileus," "intestinal paresis," and "ileus" are frequently used. In studying the literature it is
sometimes difficult to determine for sure what type of "ileus" the writer was in mind.

The importance of postoperative paralytic ileus, along with many other phases of the condition is a matter of some dispute. None other than McIver makes such a remark as "This group (referring to postoperative paralytic ileus), is of minor importance." Whereas, Cutting, contends "the condition almost invariably follows abdominal operations and sometimes becomes severe enough to cause considerable concern." Stout in a recent publication makes the following statement, "$\text{The prevalent opinion seems to be that ileus (meaning postoperative paralytic) is an uncommon condition. This opinion is, however, erroneous as just the converse represents the truth in the matter. Ileus is a very frequent postoperative complication with which surgeons have to deal. The abdominal distention and distress from "gas pains" suffered by many postoperative patients are too often not recognized for what they really are, namely, some of the symptoms and signs of an incipient ileus.}"

It should be pointed out that the condition which is herein being discussed is one which is
primarily a functional disturbance of the intestines, a fact which will be appreciated as the thesis is developed, and like most functional conditions it can and does exist in various degrees of severity. That is to say, by paralytic ileus we do not have in mind the condition in which the bowel is found following a neglected case of mechanical obstruction in which all signs of motility and tonicity have long since vanished, but rather, by postoperative paralytic ileus we are speaking of that condition which we believe so frequently follows an operation and which in some instances is clinically indicated by only mild degrees of nausea or a few "gas pains", whereas in other case it may be indicated by severe abdominal distention, pernicious fecal vomiting and dehydration, sufficient to cause concern for the life of the patient. In other words we interpret the term to include these two extremes and all the intermediate degrees existing between them.
ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS.

Physiologists are quite well agreed on the types of motility present in the normal intestine. Maltzer and Auer(6) published a discussion of the subject which has since become a classic. They described three types of movement which are generally recognized to be present in the normal intestine:

(1) Pendular movements, rhythmical swaying motions which apparently contribute but little to the forward expedition of the intestinal contents. According to Bayliss and Starling(7) and to Cannon (8) the pendular movements are chiefly concerned with the thorough mixing of the food with the digestive fluids, they are the essential factors in the "rhythmic segmentation" observed by Cannon(8).

(2) Peristaltic movements, which consist of a contraction of the gut above a food mass and a relaxation below. This is the "law of the intestine" as first described by Bayliss and Starling(7), or the "myenteric reflex" as described by Cannon(9). This movement is concerned in carrying the food through the intestines in the aboral direction. Its progress is slow.
(3) Peristaltic rush, a fast running movement extending over the whole or a large section of the small intestine. It is "A rapidly progressing wave of contraction preceded by a completely relaxed long section of the intestine through which fluid contents mixed with gas bubbles is rapidly driven. Meltzer and Auer (6)

When we turn our attention to a consideration of the mechanism by which these forms of motility are performed, we at once encounter differences of opinion. These differences of opinion are embodied in two broad theories of the mechanism of intestinal peristalsis and are the Neurogenic and Myogenic theories of intestinal movements. While there seems to be no conclusive evidence on which to decide between the two theories, it may be pointed out that the chief types of intestinal movements, that is, the rhythmic contractions and the peristaltic waves may depend upon different mechanisms, the former simpler and more primitive movement being simply a function depending upon the well-known inherent ability of smooth muscle to contract in a rhythmic manner, while the more complicated and highly developed peristaltic wave may depend upon
the nervous elements for its initiation and propagation. This is a point of some practical importance in considering the functional disturbances of motility; for diverse types of injury, as we shall later see, may affect different portions of the neuromuscular mechanism.

The intestines have an intrinsic and an extrinsic nerve supply. The intrinsic innervation consists of two nerve plexuses in the intestinal wall; the submucous plexus, (Meissner's plexus); and the more important myenteric plexus (Auerbach's plexus), which lies between the circular and the longitudinal muscle layers and serves to conduct stimuli and to coordinate movements. Upon this plexus depends the local reflex, the "myenteric reflex" of Cannon (9) and Bayliss and Starling's "law of the intestine"(7). This reflex governs the orderly progress of the intestinal contents, a wave of contraction being preceded by a wave of relaxation. Alvarex(10) questions the importance of the myenteric reflex in the propagation of the peristaltic wave. According to his view the downward passage of a wave is due to "gradients of irritability, tone and metabolism," between the
upper and the lower portions of the intestinal tract for he points out(11) that these activities continue after degenerative section of the vagi and splanchnic nerves, and that possibly the peristaltic rush continues after removal of the bowel from the body. He noticed that bits of intestinal muscle cut out and suspended in oxygenated Lock's solution would contract rhythmically for hours at a time, and the fact that they would sometimes beat more regularly on the third day after excision than on the first, suggested strongly that nervous ganglia had little to do with the phenomenon.

Although the intrinsic innervation is complete in itself, and capable of carrying out in an orderly manner all types of peristalsis without connection with the central nervous system, under normal conditions it is influenced by impulses from the central nervous system, transmitted over two opposed systems, represented by the parasympathetic (cranio-sacral or vagus) whose impulses tend to stimulate intestinal movements and increase tone; and the inhibitory system, consisting of the sympathetic fibers (splanchnics) whose impulses tend to abolish intestinal movement, Bayliss and Starling (12)
It should, however, be pointed out, as Alvarez(13) indicates, that the effects of vagus and splanchnic stimulation are by no means uniform and contradictions present in the literature on the subject, exist, because the smooth muscle of the intestine responds with so many different combinations of relaxations and contractions. Probably everything depends on the state of the organ when the stimulus arrives, i.e. whether it is fatigued or fresh, contracting or relaxing, etc. The sympathetic system also carries motor fibers to the pyloric and ileocecal sphincters.

**Physiology of Intestinal Gases.**

Besides intestinal motility, an equally important function of the intestine, as related to abdominal distention, is that of the physiology of the gases formed, or otherwise present within the lumen of the intestine, together with the method of their excretion. Writers generally agree that the gases commonly present in the normal intestine are carbon dioxide, marsh gas, \((\text{CH}_4)\), hydrogen, nitrogen and occasional traces of indol, skatol, hydrogen sulfide and ammonia, the last mentioned one is formed from the putrefaction of
of proteins. The last four gases are odoriferous; marsh gas and hydrogen are inflammable. Writers are further generally agreed that the atmospheric air entering the stomach during swallowing and the gases arising in the intestinal tract by fermentation are modified by the interchange with the gases of the blood stream.

According to Kantor and Marks(14) the greatest part of the gas produced by food digestion is carbon dioxide. It has the following sources: (1) In the upper small intestine, from a mixture of the acid gastric contents with the carbonates present in the alkaline biliary and pancreatic secretions. The amount thus manufactured has been estimated at six liters daily(14). (2) In the lower small intestine from the possible bacterial decomposition of sugars. It is to be recalled that sugars and starches are normally broken down by enzymic action to monosaccharids which are readily absorbed as such. It does not seem likely, that in health, much monosaccharid would be available for decomposition to carbon dioxide by bacterial action. At any rate no figures are available in the literature. (3) In the cecocolon from the bacterial decomposition of cellulose there being, in man, no enzyme capable
of attacking this substance. Cellulose produces carbon dioxide when neutralized by the alkaline carbonates secreted by the proximal colon.

McIver, Benedict and Cline(15) demonstrated that atmospheric air enters the stomach, as "swallowed air" during eating and especially while drinking, and that by far the greater part of the ingested air was normally quickly belched. What little is left in the stomach assumes significance because it is composed of eighty percent nitrogen which they demonstrated, is practically unabsorbable by the body. This, together with twenty percent oxygen, which is absorbed in part only, accordingly, is forced to make the transit of the entire digestive tract, and appears almost quantitatively in the flatus. Kantor and Marks(14).

Fries(16) has estimated that the volume of gas discharged daily through the rectum in health amounts to about one liter. Inasmuch as much more gas than this is formed, the conclusion is obvious that a large percentage of the gas must be excreted through other channels.

Gas absorption has been shown to follow the
physical laws of diffusion. Dunn and Thompson(17) and McIver(18). It has been definitely demonstrated that the walls of the intestine are permeable to gases and that an active interchange takes place, tending to keep the gases on the two sides of the mucosa in equilibrium. As Alvarex(10) has pointed out, the chief feature of interest in this connection is that when nitrogen is diffused into the bowel, it is not reabsorbed, not only because of its low diffusion constant, but also because the blood and the tissues are already saturated with this gas.

The rates of diffusion for these various gases found in the intestine have been experimentally determined by McIver(18) by introducing measured amounts of these gases into a closed loop of intestine in cats and subsequently measuring accurately the amount of absorption which occurs per unit of time. The number of cubic centimeters of various gases absorbed from the loop of intestine twenty-five inches long per hour are represented essentially as follows:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Absorbed (cubic centimeters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>160</td>
</tr>
<tr>
<td>HS</td>
<td>69</td>
</tr>
<tr>
<td>O</td>
<td>14</td>
</tr>
<tr>
<td>H</td>
<td>7</td>
</tr>
<tr>
<td>CH</td>
<td>2</td>
</tr>
<tr>
<td>H</td>
<td>1</td>
</tr>
</tbody>
</table>
McIver also demonstrated, that when the circulation of the intestine was interfered with that the reverse process of gaseous diffusion took place, viz: the diffusion of CO into the lumen of the intestine resulted and an increase volume of gas within the intestine was produced.

Intestinal flatus, therefore, is to be regarded as a result, and, at any given moment, of air admixture, gas production from food digestion, gas absorption from the intestine and possible gas diffusion into the intestine. The last named factor being probably unimportant in health. In flatus, as might be expected, it is the unabsorbable gases that predominate, as may be seen in the following analysis of Fries(16)

<table>
<thead>
<tr>
<th>Gas</th>
<th>Volume Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>10.3 Vol. percent</td>
</tr>
<tr>
<td>O</td>
<td>0.7 Vol. percent</td>
</tr>
<tr>
<td>CH₄</td>
<td>29.6 Vol. percent</td>
</tr>
<tr>
<td>N</td>
<td>29.4 Vol. percent</td>
</tr>
</tbody>
</table>

In as much as no nitrogen is produced during digestion, all of this gas is assumed to result either from the air originally swallowed, fermentation, and from gas secreted from the blood in the process of equilibration.
The amount of gas passed per rectum is estimated at one liter daily. Fries(16). This is to be contrasted with the much greater amount absorbed. (Tacke) from Kantor(14), working with rabbits, found that ten to twenty times as much intestinal gas escaped by the lungs as by direct expulsion from the lower bowel. The figures for man are unavailable.
MECHANISM

So far we have discussed the normal physiology of the intestine with reference to motility and the gases present in the intestine. We shall next turn our attention to a consideration of these functions with reference to the mechanism by which postoperative paralytic ileus is produced.

Abdominal distention, resulting from postoperative paralytic ileus implies that there are two features of paramount importance in the condition. They are 1. the gas and other substances which are present in the intestine and producing the distention and 2. the disturbed or paralyzed motor activity of the intestine. We shall first consider the problem of the gases and the mechanism by which these gases are able to produce a positive pressure within the lumen of the intestine which we recognize clinically as distention.

The nature of the gases in postoperative ileus is not essentially different from that found in the normal intestine. McIver, Benedict and Cline(15) and Boycott and Damant(19) studied these gases and found that carbon dioxide, oxygen, nitrogen, methane, and sometimes hydrogen sulphide were the gases com-
monly present, their proportions being subject to considerable variation. Authorities generally agree that the sources of the gases in postoperative distention are much the same as the sources of normal intestinal gases, viz: swallowing, equilibration with gases of the blood stream and chemical changes in the intra-intestinal matter found in the decomposition of intestinal contents. However, the mechanism, by which these gases are able to produce a pathologic condition of distention might be stated as being represented by an alteration or exaggeration of the normal. We shall now consider in some detail these alterations and exaggerations of the normal.

Swallowing:

Air taken into the stomach in the action of swallowing, McIver, Benedict and Cline (15) emphasize the importance of this source of gas in postoperative distention. They approached the problem from an experimental and clinical standpoint. Clinically, in following one hundred and seven cases on which laparotomies were done, mostly under ether anesthesia, they found that postoperative dilatation of the stomach was not uncommon. They noticed that
in a considerable number of cases that a great deal of air was swallowed during the early stages of anesthetization. Again, they noted, that because of the great dryness of the mucous membrane of the mouth and pharynx as an after effect of ether, that many patients would make an effort to relieve this by swallowing motions which carried air into the stomach. They felt also, that the air taken into the stomach with liquids which were taken after an operation was responsible for a considerable intake of air, and they believed it was also possible that during the stretching which accompanied postoperative nausea and vomiting, air might be gulped down.

McIver(20) also discusses the condition of acute dilatation of the stomach occurring under general anesthesia, and considers that although it is uncommon, and the etiology is probably not known, it does occur and is to be regarded as one source of gastric distention.

Having established as a fact, that postoperative gastric distention was a common finding, McIver, Benedict and Cline(18) proceeded to demonstrate experimentally that this gas in the stomach was frequently passed on into the intestine, and con-
sequently gave rise to the clinical condition so commonly seen. They point out that paralysis of the intestine does not cause abdominal distention and that there must be a source of gas which is capable of producing the positive pressure within the lumen of the gut. For their experimental work they employed cats, anesthetized them, opened the abdomen and injected air into the stomach; from 60 to 90 cc. which caused a moderate degree of distention. Cats' stomachs which were thus distended usually set up vigorous peristaltic waves, which were capable of passing the gas into the lower intestinal tract. If while the stomach was distended, the vagus and splanchnic's were sectioned, the motor activity of the stomach and intestinal tract was increased. Under this condition the gas was invariably passed from the stomach into the intestine.

When the vagus was stimulated with the stomach distended by gas, a great motor activity of the stomach and small intestine was produced, but in no case was any gas observed to pass from the stomach to the intestine. This result they expected, since the increased tone and the contractions of the pylorus and duodenum would act as barriers to the
passage of gas downward.

When strong stimulation was applied to the splanchnics, major and minor increased tone in the stomach and an increased peristaltic motility was noted in a number of cases and gas was passed down into the duodenum. This increase in tone and peristalsis they believed was due to a reflex over the vagus, for when the splanchnics were cut and the proximal end stimulated a similar result was obtained. Stimulation of the distal end produced the typical inhibition of the movements of the stomach and intestine. In certain cases during the increased activity following the period of inhibition, gas was passed down. They suggested that afferent impulses passing by was of the splanchnics might be effective in causing a passage of gas from the stomach into the lower intestine.

On the basis of the foregoing remarks it is altogether probable that one of the principal mechanisms which contribute to postoperative meteorism, is the gastric distention produced by air swallowing, and subsequently passed on into the intestine. We shall next consider a second source of gas and its mechanism, namely, that produced by the de-
composition of intestinal content.

McIver(3) states that this source of gas is probably one of the most important in cases of mechanical distention. No experimental work is available with reference to paralytic ileus, per se, Boycott and Damant(19) found that goats produce in their roomy stomachs and ceca from ten to thirty cc of hydrogen and methane per kilogram per hour, so that an average goat of twenty kilograms would, in one day, produce nine liters. According to Alvarez (10) the amounts of carbon dioxide evolved in the ceca of the herbivores and excreted through the lungs are so large and so hard to measure that they inject a considerable error into the calculations of the respiratory quotient. The gas produced in the intestinal phase of digestion as described in the section of physiology no doubt contributes considerably to the gases of distention.

The amount of gas in the paralyzed intestine probably depends to some degree on whether the intestine was empty at the time or to what stage digestion had proceeded since the presence of partially digested food of course, greatly increases the likelihood of active fermentation and gas formation.
The fluid that sometimes accumulates in the large amounts in a paralyzed intestine is derived from several sources. In the first place, there is the fluid that reaches the intestine from the stomach consisting of ingested fluids, saliva and gastric secretions from the liver and the pancreas; and finally there is the abundant outpouring from the intestines themselves. Dragstedt(21) has suggested that certain products of decomposition formed in an obstructed intestine, when absorbed, act as secretagogues and further augment the secretion from the digestive glands and intestines. Most of the increased secretion is probably best regarded as the result of irritative processes. That injury or irritation of the nerve endings in the intestinal walls may be an important factor is suggested by the fact that cutting the nerves to an intestinal loop is capable of producing copious secretions, the so-called "paralytic secretion" McIver(3).

Disturbances of Intestinal Motility:

As was pointed out in the section on intestinal physiology, the mechanism governing the highly coordinated movements of peristalsis is complicated.
Functional disturbances of intestinal motility may be the result of local or intra-abdominal pathology, or may be a reflex response to general or distant bodily pathology, for example, we may have an atonic paralysis of the intestines as a result of acute peritonitis; or on the other hand, the passage of a renal stone or certain other lesions of the kidney may cause reflex vomiting and a cessation of peristaltic movements. It at once becomes apparent that intestinal motility depends upon the muscle structure of the gut wall, with its local nerve supply through the splanchnic and vagus nerves. Thus, injury to the muscle or nerve elements in the gut wall might abolish peristalsis; or reflex impulses transmitted over the extrinsic nerves might bring about the same result.

It is apparent, then, that in the case of postoperative meteorism we may be dealing with a condition in which the injury, if the operation was a laparotomy, and the intestines were traumatized, may be entirely without the abdominal cavity or retro-peritoneal, as in operations on the kidney, in which event the resulting distension must of necessity be considered on the basis of a reflex...
phenomenon. Cannon and Murphy(22) showed experimentally that distant pathogenic processes were capable of inhibiting intestinal movements. They noted in the first place, that asthenic states occurring in the course of general infections tended to abolish or inhibit intestinal peristalsis. Next they studied the effects of powerful sensory stimuli which they produced by injury to the testicles of the anesthetized cat, and found that such sensory stimulation also caused an inhibition of intestinal movements. These authors further showed that the stoppage of intestinal movements under the foregoing conditions was due to inhibitory impulses from the spinal cord, transmitted over the splanchnic nerve; for when they sectioned this nerve the inhibition was abolished. This reflex mechanism, whereby distant lesions are able to bring about an inhibition of intestinal movements is now generally accepted. The experimental observations of Cannon and Murphy have been recently confirmed by King(23). There seem to be various and unexplained factors involved in this reflex mechanism. Engel(24) mentions that upper abdominal operations are more prone to cause distention than pelvic operations. He
agrees with Bonney(24) that distention is more likely to be marked after operations involving a wide area rather than a restricted one, and after those necessitating a large amount of tissue trauma rather than a small amount, however, Bonney(25) points out that according to his experience there is no fixed relation between the magnitude of the operation and the degree of the derangement.

Cannon and Murphy in the work referred to in the preceding paragraph, also investigated experimentally the inhibition of intestinal peristalsis that follows trauma to the gut. They found that they were able to produce strong inhibition of the intestinal movements by rough handling of the intestines (of the anesthetized cat), and considered that the inhibition of movements following this type of injury was probably due to direct injury to the neuromuscular mechanism of the intestinal wall. They were of the opinion that inhibitory impulses from the spinal cord did not play any role in this instance, for the inhibition was not removed by section of the splanchnic nerves.

Alvarez(26) agrees with the idea that a reflex from a distant pathological lesion contributes to
intestinal inhibition, but does not believe that
the neuromuscular mechanism plays a part in intra-
abdominal injuries. He offers as an explanation
that there is a flattening or reversal of the normal
gradient of forces and an excess of nervous inhibi-
tion, and speaks of "a flat-gradient ileus." He
points out when the vagus is cut that most of the
myenteric plexus degenerates after a period of
several weeks, Johnson(65), but intestinal motility,
nevertheless, continues. However, when turpentine
was injected into the terminal ileum there was a
slowing of the rush wave as it approached this
region; their progress was slowed even more strik-
ingly than it was in animals with normal nerves.
He concluded that flattened gradients did have
something to do with the failure of conduction in
such conditions. Ochsner(28) states that there is
a direct proportion between the amount of injury to
the intestine at the time of operation and the
extent of distention which will occur.

Aside from gross mechanical trauma to the in-
testine, peritonitis of bacterial origin may, as is
well known, seriously interfere with intestinal
motility. The various views as to the mechanism
by which peritonitis brings about functional inhibition of intestinal movements are vague. Cannon and Murphy(22) assumed that both muscle and nerve plexuses were affected by the edema and inflammation resulting from the action of the bacteria and their toxins and that section of the splanchnics, therefore, should not abolish the inhibition. Arai(26) produced peritonitis in cats generally by the injection of compound solution of iodine but sometimes also by the injection of cultures of staph and colon bacilli. He used a dose that in most cases would allow the animal to recover. He then gave a barium meal and watched the behavior of the digestive tract under the roentgenoscope. At the height of the peritonitic inflammation the progress of material through the bowel was slowed everywhere but in the proximal segment of the colon; there the feces traveled rapidly. The lumen of the bowel appeared to be widened so the tone of the muscle was probably a little low. The stomach relaxed and its movements were slow. Rhythmic segmentating movements and rushes were seldom seen.

Arai next cut the splanchnics in a number of animals and after observing that in them peristalsis
was more active and the progress of material through the gut more rapid than normal, he injected iodine or bacteria and produced peritonitis as before. To his astonishment he then found that in these animals peritonitis had no affect on the rate of progress of food down the bowel, and he was driven to the conclusion that all the slowing that he had seen before must have been due to nervous inhibition. Similar observations were made by Hotz.

These observers concluded, as did Alvarez(26) that in some cases of ileus even with peritonitis, the intestinal muscle is still capable of active contraction and only held in leash by nervous inhibition. Alvarez suggests that in addition, conduction down the bowel may be made difficult or impossible by a flattening or reversal of gradients.

When Hotz produced a severe fatal peritonitis he found that the muscle of a loop would continue to contract rhythmically even when the peritonitis was so severe that the serous coat was covered with a thick layer of pus. Rhythmic contractions ceased only after the bowel had, for several hours, been distended with gas.
In the section on mechanism we discussed, how, following an operation or laparotomy, the intestine was frequently in a state of quiescent inactivity and atony, due to the trauma of handling, dhilling and drying during the operation, and pointed out that this paralysis of the intestine might also be produced by a reflex. We noted that the intestine remained in this state for varying lengths of time following a laparotomy and Cutting(4) states that when the activity and tonicity are first resumed, tend to be disorderly and valueless. We further discussed, how, by swallowing, fermentation, and diffusion with the gases of the blood, this paralyzed intestine was able to be brought into a state of actual ballooning by the gases. The pathological picture that is found in the intestine itself is essentially one which results from the increasing distention of the bowel, for in such cases it has been shown that when the gaseous pressure within the lumen of the gut has reached a pressure of from 55 to 65 mm mercurey, blood vessels within the intestinal wall are compressed, that is the small capillaries, this not only adds to the distention
by allowing the gases of the blood to pass into the lumen of the gut, but diminishes the normal absorption of gases from the intestinal tract. This tends to produce a vicious circle in that as a result of the increased intra-intestinal contents and pressure the blood vessels within the intestinal wall are further compressed, which in turn aggravates the paralytic ileus. Ochsner(28). As a result of the increased intra-intestinal pressure and the early compression of the venous return from the bowel, there occurs within the wall of the intestine, edema, and even infarction on the antimesenteric border. Mueller(Ochsner)(28) has found in animals with adynamic ileus that the muscle cells of the intestine become hydropic, elongated, enlarged and swollen.
PATHOLOGICAL PHYSIOLOGY:

Given such an intestine as described above where the motility is diminished or absent, the absorption is decreased or nil, the secretion of gases and fluids into the lumen is increased and excessive, it at once becomes apparent that disturbances of the general body physiology are bound to accrue. We know that the function of the upper gastro-intestinal tract is secretory and digestive, whereas the lower part of the gastro-intestinal tract is absorptive, and that normally large quantities of secretion rich in electrolytes are emptied into the upper intestinal tract from the stomach, the duodenum, the liver and the pancreas. This transported into the lower intestinal tract, whence fluid and electrolytes are reabsorbed into the blood stream. In the presence of ileus, however, it is apparent that the normal transportation of the secretions of the upper portion of the intestinal tract to the lower portion is abolished, resulting in stagnation of the secretion in the secretory portion of the gastro-intestinal tract, from which little or no absorption occurs, Ochsner(28). If to this condition is added the dehydration of fluids as a result of with-holding
of fluids preoperatively for a period of hours (which is usually erroneously done) together with an insensible water loss (in perspiration and expired air), which according to Coller and Maddock (29) amounts to as much as one thousand or fifteen hundred cc in twenty-four hours, plus the fluids and electrolytes lost through vomiting which frequently occurs as a symptom of the ileus, one should have little difficulty in appreciating the fact that under such conditions there can and does occur severe upsets in the water and mineral balance of the body fluids. Rowntree (30) estimated that for an adult the secretion of digestive fluids, taken together, amounts to between five and seven liters daily. This is two or three times the volume of the blood plasma which is the immediate source of these secretions.

It becomes apparent that important changes will occur in the composition of the blood plasma following a severe ileus, the more important being a decrease in the chlorides, and an increase in the alkali reserve and a rise in the non-protein nitrogen, as shown by the experimental investigations of Haden and O'Mr(31).
McIver(3) brings out a very practical point in relation to the disturbance of the electrolytes and dehydration, in cases of intestinal obstruction and which is likewise probably applicable to cases of severe paralytic ileus. He points out that the principal basic ion in the blood and body fluids is sodium and the chief acid ion is the Cl ion, and since these ions are derived from the blood plasma, and under ordinary circumstances in a great part returned to the plasma following the periods of digestive activity which together with abundant replacement from the food intake; in cases of severe ileus this mechanism is disturbed. According to his concept the consequent depletion of the total ionic content of the plasma and the interstitial body fluids will be accompanied by an approximately parallel loss of water with the result that a normal total ionic concentration tends to be sustained at the expense of reduction of volume. That is, dehydration is regarded as a result of the loss of electrolytes; and an important corollary of this view is that dehydration cannot be repaired by the administration of water alone; an attempt to restore
and sustain the original volume of the blood plasma and of the interstitial body fluids must include replacement of the lost electrolytes. An additional theoretical point has been brought out by Gamble and Ross (32) viz., that loss of sodium rather than loss of chloride ion is the significant factor in determining the extent of dehydration, since the loss of chloride ion is compensated for within the body fluids by a corresponding increase of bicarbonate.
DIAGNOSIS

Symptoms and Signs

Obviously the symptoms of ileus are abdominal distention which may be of varying degree. The patient is frequently nauseated and usually vomits. The important consideration in postoperative distention is to determine whether it is paralytic or mechanical. Ochsner(28) states that as a rule an ileus developing within the first twenty-four to forty-eight hours postoperative is of the adynamic variety, whereas that developing several days after laparotomy is usually of the mechanical type. When associated with peritonitis, however, it may be either adynamic or mechanical.

In mechanical ileus the pains are of a recurrent colicky nature, whereas the pain, if present in adynamic ileus, is more apt to be continuous, of a dull, aching or boring character. The patient may or may not appear ill, depending upon the extent of the involvement. Auscultation of the abdomen in adynamic ileus is an absence of peristalsis and peristaltic sounds, (silent abdomen) in contrast to mechanical ileus in which the peri-
staltic sounds are increased. Ochsner places emphasis on the value of X-ray in the diagnosis of the more severe cases.
TREATMENT

The problem of treatment in postoperative paralytic ileus will be considered from the stand-points of: (1) the general measures including pre-operative treatment and general postoperative measures. (2) Methods of stimulating the bowel, and (3) Methods of decompression.

Time nor space does not permit here a complete discussion of the subject of preoperative care of a patient. In this thesis we are interested in the problem of postoperative paralytic ileus, we shall therefore, confine our discussion of preoperative care to those measures which have been found to be related to the condition of postoperative distention.

Preoperative Measures:

As in any surgical condition the patient should receive the usual routine care and treatment, which includes the use of narcotics and atropine or scalolamine as determined by the preference of the surgeon, the only mention of these drugs as related to postoperative meteorism is made by Glass and Wallace(33) who advocate a combination of morphine with magnesium sulphate. They believe that the
morphine lessens the incidence of intestinal paresis, acidosis, and nausea and vomiting, bronchial and renal irritation, and that the combination with magnesium sulphate usually prevents the necessity of giving additional doses postoperatively.

Gwathmey (34) advocates the hypodermic use of morphine sulphate, gr. 1/8 dissolved in 2 cc of a fifty percent solution of magnesium sulphate, to be repeated once or twice, according to conditions, at intervals of twenty to thirty minutes. This represents about 1/100 of the lethal dose of magnesium sulphate. He believes that there is a synergistic action in this combination. This solution has been injected into over twenty thousand cases at the Lying-in Hospital of New York, with the production of a negligible number of sloughs (about seven cases). He cites two parallel series of 200 cases each. In one series morphine alone was used, in the other a combination of morphine and magnesium sulphate; in the first series of cases a postoperative sedative was required, on the average, four hours after operation in the second series, not for sixteen hours.
Naturally the pre-operative care of the gastrointestinal tract should receive close attention since it is here, if the pre-operative treatment is faulty, that we should expect to find evidence of it in terms of postoperative distention.

The practice of withholding food for twelve to eighteen hours prior to the performance of abdominal operations, formerly in vogue, has, according to most present conceptions, little to recommend and much to condemn it. Emptiness of the gut is not essential or even desirable according to Cutting (4). He states that patients may ordinarily be allowed to eat such articles of diet as are provided in the regular hospital dietary, or such food as their particular inclinations may dictate, up to the evening meal preceding the day of operation. This meal must be easily digestible, consisting possible of soup, boiled fish or chicken, spinach, butter, toast and jelly. Potatoes, cheese, strong tea and coffee, fried foods, and the like are interdicted; no limit, however, need necessarily be placed on the amount of approved foods eaten. Later in the evening if the patient is inclined to be restless and cannot sleep, hot milk or some other hot drink
may usually be given. No food is ordinarily allowed on the morning of operation but water may be freely taken up to an hour or so preceding the operation; a cup of hot tea or coffee sweetened but without cream, may be substituted in case the patient does not relish plain water. This old idea of admitting no solids into the alimentary tract within half a day of the operation, and the removal of all intestinal contents already there, apparently was designed not only to produce the best possible condition of the patient and his viscera for surgical interference, but also to guard against postoperative distention. Mitchell(35). He believes that its failure to accomplish this end was not surprising since it was based on the irrational thinking that an empty bowel was the best bowel for operation, whereas the truth of the matter is, an empty bowel lacks the normal stimulus to peristalsis - namely the intestinal contents. According to Mitchell(35) the strongest argument against the preoperative starvation of a patient is the fact that such withholding of food predisposes to acidosis, or the lowering of the alkali reserve in the blood. This
sequel is the more liable to follow in children, particularly in those cases where a septic process is at work, and when chloroform or ether, but especially the former, is used as the anesthetic. It is said that even the mild attacks of vomiting that occur after most laparotomies are due to a slight degree of acidosis. Mitchell believes that this vomiting is accentuated, not relieved, by preliminary starvation for too long a time.

Purgation:

Formerly, purgation and starvation, both as complete and possible, were the order of the day, the paramount consideration in the mind of the surgeon seemed to be the emptiness of the whole alimentary tract. The usual purgative was castor oil. The action of this drug is well known; in the duodenum it is transformed into ricinoleic acid which is a powerful intestinal irritant, so powerful that it causes reddening and swelling of the intestinal mucosa and stimulates the muscular coats of the intestine to active contraction, with a resultant relatively complete evacuation of the contents of the intestine. Cutting(4)
That intestinal evacuation is desirable in preoperative treatment is a proposition which is by no means universally accepted. According to Cutting (4) and Mitchell (35) the irritated condition in which the coils of the intestine are left after the catharsis and the inertia of the intestines which invariably follows a period of hypermotility, especially the latter is a most fruitful source of postoperative ileus. Alvarez (36) gives a graphic historical account of this problem and points out that this procedure of preoperative purgation is probably a hold-over from the older writers such as Burton in his Anatomy of Melancholy (1621) tells us that purges "scour the body of vomit, urine sweat and of all manner of superfluities, and keep it clean." Alvarez further points out that the preoperative purgation is at the present time being given up by many surgeons, however, he says "there are some reactionaries who are pleading for a return to drastic preparation, and claiming that it is a sure cure for all postoperative troubles."

Alvarez (37) attacked the problem experimental with rabbits in 1917. He used castor oil, magnesium
sulphate, calomel, cascara and jalap, and after purging the animals opened their abdomens and examined the intestinal coils. In the thoroughly purged animals the bowels were injected, full of fluid and gas, sometimes atonic and flabby, often irritable here and there and inclined to contract down into hard white cords. The contractins of the intestines were weak and irregular and soon became fatigued. In the moderately purged intestines he found gas and "other abnormalities." He concluded that in such a well purged rabbit's bowel full of gas and fluid that the mesenteric circulation was disturbed. Excised segments beat poorly and irregular in Locke's solution and fatigued quickly. They responded poorly to drugs, some parts were abnormally irritable while others failed to respond at all to powerful stimuli. This unevenness in the gradients of muscular forces which he believed to be present must interfere, he concluded with the steady progress of food through the gut and probably favored the production of colic and gas pains. He further concluded that to purge shortly before an operation in which the bowel must stand the
results of drying, handling etc. would be most unwise.

Alvarez(37) further points out that the small intestine is empty in from seven to nine hours after a meal. Since operations are usually performed in the morning from twelve to eighteen hours after dinner there would certainly be no need for giving a purgative to clear the small intestine. The only place left in which feces could stagnate is the colon; and, in most cases that also would empty itself spontaneously on the morning of the operation, if it were left alone. Failing this, it could easily be cleared by enemas. Woodyatt and Graham(38) have shown that the blood may not only fail to carry the gas away from the intestine, following severe purgation and the mesenteric circulation has been disturbed, but it may, on the contrary, even exhale some into the bowel. Such an exhalation would account best for the sudden accumulation of gas so frequently seen in man. Crile(39) says, "It is a serious mistake to starve a patient too long, or to purge too severely before an operation." Cutting(pg.206 34) suggests that if a laxative is
is indicated, petrolatum is to be preferred, because its action is purely that of a mechanical lubricant, and its use therefore, entails no undesirable or unknown side actions of a pharmacological nature.

Enemas:

An enema may be given if desired in the evening preceding the day of operation; if administered, it should be given relatively early to avoid disturbing the patient's rest unnecessarily. The literature offers no opposition for the use of enemas preoperatively.

On the morning of operation the lower bowel should always be emptied by enema unless some contraindication exists, and this not less than one and one-half hours before the time set for operation. If an enema be given subsequent to this time absorption of any fluid inadvertently left within the bowel may be incomplete and the patient's bowels may move on the operation table.

General Post-operative measures:

Aside from the special methods of treatment which will subsequently be discussed there are several important points with relation to the routine post-
operative care of the patient which have a direct bearing on the problem of distention, and which should be mentioned. These will be discussed briefly; some of them will be added to in subsequent pages of this thesis.

Post-operative use of Morphine:

The action of morphine on intestinal motility has ordinarily, in the past, assumed to be one of inhibition of peristalsis and decreased intestinal tone. The most recent work, however, on this subject by Plant and Miller(40) shows, in both humans and dogs, that morphine in the doses ordinarily used, increases, the tone and to some extent, the peristaltic activity of the small intestine and colon. These observation have been confirmed by Orr(41) and others. Ochsner, Gage and Cutting(42) found that the principal effect of morphine on intestinal activity was to increase the tone without affecting the peristaltic movement materially, they thus concluded that it was of value in paralytic ileus because it prevented abnormal distention of the bowel by the accumulation of gas and fluid. They stated that it would exert a similar effect on
the gut which was already distended and would produce tonic contractions of the bowel as effectively as any other measure. They believed that its greatest value was in those cases in which it was used prophylactically before distention occurred. The dose of the drug, obviously, depends upon the age and size of the patient. Ordinarily in an adult with functional ileus, morphine gr $\frac{1}{2}$ was administered every four hours and continued until normal gastrointestinal extivity was resumed, which was usually after twenty-four to forty-eight hours. Ochsner (43) suggested that the dose of morphine used in severe types of adynamic ileus be proportional to the extent and severity of the peritoneal irritation. The postoperative use of morphine is now the generally accepted idea and current opinion agrees, generally, that it is of value in preventing and aiding post-operative distention. McIver(3) suggests gr. $\frac{1}{6}$ every three hours, may not be excessive, although the respirations should be carefully watched and if they fall below sixteen per minute the quantity or frequency of the dose should be reduced.
Postoperative Feeding:

Ochsner(43) believes that those procedures which overburden the gastro-intestinal tract during the period of functional inactivity, should be avoided, and he states that it is imperative that the patient receive nothing by mouth during this period, because such substances taken into the stomach will not be transported downward into the intestinal tract. McIver(3) is of a similar opinion and remarks that the early administration of fluids provides a means of introducing atmospheric air into the stomach by swallowing, and further, that what the intestines need during the period of paresis due to trauma etc. sustained during the operation, is rest and to administer substances per mouth during this period serves to increase the time necessary for the intestine to recover from the traumatic shock. Ochsner(43) adds further that it is important to avoid giving those substances postoperatively which predispose to gas formation. He observed that the administration of sweetened juices, such as orange juice and other sweet drinks, increased abdominal distention and the patient's discomfort, and for
this reason did not permit their administration until the intestinal activity had become normal. Recently Fine and Levenson(44) showed that, although dilute glucose solutions are absorbed readily in the normal intestine, whenever there is disturbance in intestinal function, abnormal gas formation results. Ochsner contends in his experience, everything else being equal, the amount of postoperative abdominal distention is directly proportional to the frequency and the amount of sweetened drinks ingested. Alvarez(10) on the other hand contends that the intestinal contents is the natural physiologic and best stimulant of intestinal peristalsis and suggests, that, from this principal surgeons should take a cue and believes that the frequency of postoperative distention would be decreased by the dearly administration of foods following an operation.

McIver, Redfield and Benedict(18) showed that inhalations of pure oxygen favor the absorption of nitrogen from closed loops of bowel. Fine, Sears and Banks(45) showed that in the experimental animals only 3.4 percent of the total gas volume from the
intestine was absorbed after twenty-four hours; but after the administration of oxygen there was a progressive decline in this volume until a maximum reduction of an average of 59.2 percent was reached. These investigators have shown also the necessity of prolonged administration of oxygen for at least twelve hours, rather than short, sporadic administrations. The postoperative administration of oxygen has thus become a routine in osme clinics, following laparatomies, Ochsner(43)

Enemas; amd cathartics

Ochsner(63) points out that a patient who has taken little or nothing by mouth preoperatively, has relatively little residue in his intestinal tract for several days following operation and so it is immaterial whether he defecates during the first three or four days or not. He states that it is illogical and corroborated by clinical experience that the patient with a functionally inactive gastre-intestinal tract will be almost as ineffectual in evacuating the fluid introduced rectally as he is in evacuating his own intestinal fluid and gas. He believes that the symptoms and the abdominal distention are made worse after
the administration of enemata and flushes and states that the degree of abdominal distention and discomfort are directly proportionate to the number and size of the flushes which are administered, likewise the use of violent cathartics during the period of functional inactivity of the gastrointestinal tract should be condemned, he says, because by increasing violent peristalsis a persistent ileus can result. Cutting(4) agrees with this concept of the postoperative use of enemas. McIver (3) states that an occasional low enema is useful in getting rid of accumulation of gas in the colon, but as to frequent use of enemas is to be avoided, particularly if they are not being freely expelled. He points out that a function of the colon is to dehydrate the feces, and if the colon is being constantly filled with watery solutions that are not freely expelled, it seems likely that fermentation is increased.

Use of Heat

Heat is generally recognized to be a measure of value in postoperative distention. Ochsner(63),
Cutting(4), McIver(3) and Wagensteen(71). Ochsner employs the use of heat routinely following laparatomies because it tends to prevent the development of ileus. Cutting(4) discusses the subject to some length. He does not favor the old time-honored turpentine stupe, and doubts very much if the turpentine used in the preparation of the stupe has any particular value in itself, but thinks, rather that the value is derived from the heat content of the stupe. Because the stupes impose an increased burden of weight, their area of application is usually restricted to the bandages and dressings, they speedily lose heat and must, therefore, be changed frequently to be of value, causing much trouble for the nurse and bother to the patient. He recommends very highly the use of an electric light tent or cradle which obviates, the disadvantages associated with stupes. With a cradle or tent the supply of heat is constant and can be regulated at will, and states that the therapeutic value of the electric light cradle corresponds with its theoretical advantages.
Special Postoperative Measures

Granted that the mechanism of postoperative idstention has been accurately stated we see that the accumulation of gas in the intestine are dissipated, not so much by mechanical evacuation of expulsion, but by absorption into the blood stream. The rate of absorption cannot be hastened artificially because as we have seen, it depends upon pressure relationships and the percentage composition of the contained gases, factors which for the most part cannot be controlled. As previously stated, once distention is established, a vicious cycle is set up in which the distention itself tends to increase the severity of the distention. This then, leaves but two possibilities with which the condition can be logically dealt. They are, (1) breaking this vicious cycle by stimulating the gut with the hope of expelling some of the gas or (2) active decompression of the distending gas either conservatively or surgically. We shall next consider the methods of stimulating the gut. Three possibilities exist, they are (1) drugs, (2) splanchnic block (3) intravenous hypertonic salt solutions.
We shall now consider these methods in some detail.

Drugs:

The drugs which have been most commonly used are eserine or physostigmine, pituitary extracts, choline and acetyl choline, peristaltin, pitocin, and strychnine.

Physostigmine or eserine has been used for nearly fifty years for its stimulating action on intestinal motility. Alvarez(46) and Cross(47) examined the effects of eserine on isolated strips of smooth muscle from the intestinal tract of experimental animals. They have found generally, that the action of eserine is to increase the tone of the musculature and to produce increases in the amplitude of intestinal contraction. Many reports of the clinical use of eserine would seem to indicate that the drug is efficacious in many cases of post-operative distention. Martin and Weiss (48) used the drug and thought it useful in abdominal distention in non-toxic cases especially. According to them it was less useful in cases of the toxic type. They advocated that the drug be used in non-toxic cases and in doses sufficiently large if
results were to be expected. They employed the salicylate or benzoate in 1/20 and 1/16 grain doses, intra-muscularly and repeated in one hour and at intervals of three hours for three doses if necessary. They concluded that it was a very valuable drug when employed in this way.

Cross(47) demonstrated experimentally that eserine and pituitrin in combination had a more powerful effect in stimulating movements than either singly. He employed this combination clinically in doses of Pituitrin 1/2 and eserine 1/100 grain and relieved cases of postoperative distention where eserine or pituitrin alone failed to do so.

Martzloff(49) has made an unfavorable report on the basis of a study of the use of a combination of eserine and strychnine prophylactically in one hundred and sixty-two cases subjected to major abdominal operations under ether anesthesia. He investigations was well controlled, and he found that in patients receiving this prophylactic treatment for distention and gas pains, emesis and distention occurred more frequently in treated cases than in untreated ones and that voluntary micturation was
reestablished earlier in the non-treated cases than in the treated ones. He concluded that no benefits may be expected to result from the preoperative use of eserine and strychnine in the prophylactic treatment of these conditions. The objection to Martzloff's work might be raised that he used the drug prophylactically rather than therapeutically.

Moeninghoff (50) observed satisfactory movements of the bowel only in cases the drug treatment was supplemented by the use of an enema. Bell (51) found that defecation occurred following the use of pituitrin and believed that intestinal motility and tone were increased. He found, however, that frequently a period of relaxation preceded the institution of a strong contraction. Certain experimental investigators have attributed to pituitrin, a stimulating action, whereas others have found characteristically the exact reverse. Young (52) found that although the watery solution of pituitary substance was effective in promoting intestinal movement, the alcoholic extract was not. Dixon (53) found that, even though pituitary extract caused an increase in the movements of the small
intestine, it produced the opposite effect on the large bowel. Gross(54) was able to produce slight increases in tone in the musculature of pieces of human appendix removed at operation. Bayer and Peter(55) found that contractions occur only occasionally and always after a period of relaxation. Shamoffen( ) noted relaxation and inhibition of rhythmic contraction. Hoskins and Atwell(56) and Marinus(57) believed that extracts of pituitary gland vary greatly in their content of intestinal stimulant and that the pituitary gland is not particularly richer than several other tissues. McIntosh and Owings(58) noted slight relaxation or no change at all following pituitary injections in both normal and obstructed loops of bowel. Ochsner, Gage and Cutting(59) concluded that pituitary extract was not only ineffective but also dangerous in distention because it decreased tone and inhibited motility in a great majority of the cases.

Pitocin:

Ochsner, Gage and Cutting (59) apparently showed that pitocin is quite worthless as an intestinal stimulant.
Choline and Acetyl Choline:

Abel(1) used acetyl choline in a series of clinical postoperative cases of laparotomies and concluded that in paralytic ileus acetyl choline appeared to be almost a specific in curing the condition. Ochsner, Gage and Cutting(59) on the other hand, after experimental observations found that the action of choline was inconstant and insignificant and that acetyl choline increased the tone in forty percent of the cases, and decreased it in fifty percent. The action of these drugs they said "has proved disappointing in our series of investigations."

Peristaltin

A preparation of the soluble glucoside of cascara segrada suitable for hypodermic injection is supposed to have a specific stimulatory action on the intestinal musculature. Ochsner, Gage and Cutting(59) have presented experimental evidence, indicating that this substance is of relatively little value. They found that the effect of the drug was inconstant with respect to both tone and motility.
All in all the evidence at the present time does not offer much that is convincing as regards drugs in the treatment of paralytic ileus, either prophylactically or therapeutically. Some clinicians use them and will swear by them, others avoid them and assert that they have no place in abdominal distention. At the present time it can probably be said that drug therapy in intestinal distention, in general, stands on very precarious ground.

Hypertonic Salt Solutions:

In 1924, Hughson and Scarff(60) while investigating the problem of intravenous sodium chloride on intestinal absorption noticed that during the course of their experiments on the animals that the hypertonic salt, given intravenously had a decided stimulative effect on the intestinal motility. To quote their description of events: "as soon as the injection of the chloride solution was started, the entire intestinal tract, including the isolated loop showed marked peristaltic activity. This continued during the time of injection, usually five to ten minutes, and persisted throughout the entire period of observation, in some instances..."
fifty-five minutes. In no single instance did the intestine fail to respond in the manner described." These authors then treated the intestine of animals in a variety of ways, attempting to simulate the different forms of ileus encountered clinically, to see if the intravenous injections of hypertonic chloride solutions would have the same stimulating effect that it did on the normal intestine. They concluded it did stimulate such intestines which had been subjected to various experimental procedures designed to imitate paresis, so long as the blood supply remained intact. They applied the method clinically to two cases "with most striking results." This procedure has been used subsequently by several observers. Ross(61), Colman(62) and Ochsner(63). Ross confirmed experimentally the stimulating effect of hypertonic salt solution and reported three cases in which the method had been employed, stating that "one dose produced phenomenal results in cases of postoperative adynamic ileus, where pituitrin, eserin, enemas etc, had all been futile." Ochsner(64) showed experimentally and believed to have been able to corroborate the fact
clinically, that the intravenous administration of solutions containing calcium and potassium chloride was more efficacious in stimulating the gut activity than were solutions containing sodium chloride alone. He found experimentally in mechanical ileus, that the intravenous administration of sodium chloride in average doses of 8.4 cc per kilogram of body weight produced an increase in the intestinal activity of 90.4 percent; a decrease in 4.7 percent; and no change in 4 percent of the observations. The average increases in tone and amplitude were 28.6 and 5.05 mm respectively. The average duration of the increased activity was eleven minutes. In a similar series of animals in which a hypertonic Ringer's solution, the normal constituents of which had been multiplied by twenty, was given intravenously, the following results were obtained; in 96 percent of the observations there was an increase in the intestinal activity, in none was there a decrease, and in only two percent of the observations was the activity unchanged. The average increases in tone and amplitude were 63.8 mm and 160.07 mm respectively. The average duration of the increased activity
was eighteen minutes. The average dose of the hypertonic Ringer's solution was 2.5 cc per kilogram of body weight. Ochsner(28) later used what he termed a modified Ringer's solution. This solution contained, in addition to the sodium, potassium and calcium chloride, sodium lactate which acted as an excellent buffer and which oxidized readily. He used this modified Ringer's or hypertonic Hartmann's solution, as he termed it, in the following manner: to the contents of twenty cc ampoule of the Hartmann's solution are added five cc of distilled water, giving a solution of sodium chloride 11.7 percent, potassium chloride, 0.74 percent; calcium chloride 0.54 percent and sodium lactate 5.6 percent. This hypertonic Hartmann's solution is twenty times the strength of the physiologic solution, with this solution equally good results with intravenous administration were obtained experimentally as with the hypertonic Ringer's solution, in fact he states that there was slightly greater increases in intestinal tone and amplitude of intestinal movement following the administration of the Hartmann's than with the Ringer's. Ochsner states that he has used the hypertonic Hartmann's solution routinely in severe
cases of adynamic ileus (28) and he reports a series of cases in which it was employed. In each case the results were unusually good. In a subsequent publication, however, Ochsner (53), in which he discusses at some length "Postoperative treatment", including functional and adynamic ileus, he fails to make any mention of the use of a hypertonic salt solution, but recommends a physiologic salt solution, preferably Ringer's or Hartmann's, or a five percent dextrose solution as a means of combating dehydration. Whether or not he still employs the hypertonic solution in his clinic or not cannot be determined from his most recent publication, as he makes no comment on the value of the hypertonic Hartmann's which he had previously reported on so favorable.

A review of the literature on the use of hypertonic salt solution as a therapeutic means of combating functional ileus would lead one to believe that it offers hopeful possibilities. No evil effects from the use of the solution have been mentioned in the literature. Hughson and Scarff (60), in their original article report that the hypertonic sodium chloride solution can be given
intravenously with perfect impunity in concentrations from fifteen to thirty percent, in doses of 2 to 2 1/2 gms per kilogram of body weight the salt becomes toxic, so that the administration of one-sixth to one third of a gram per kilogram gives a distinct margin of safety, and they suggest that this dose be given. They emphasize the necessity of slow injection, not more than five cc per minute. At this rate the effect on arterial and venous pressure will be negligible. They mention that numerous reports of its clinical use in reduction of cerebrospinal fluid pressure have been made.

Spinal and Splanchnic Block.

In recent years there has appeared in the literature a considerable number of publications discussing the value of splanchnic block in cases of ileus, both mechanical and postoperative. Most of this literature has appeared in foreign journals. Ochsner, Gage and Cutting(66) made a comprehensive study of this problem with experimentally reduced ileus in dogs. For their anesthesia they used both nicotine and procaine hydrochloride. They concluded that there was little value in injective
nicotine into the splanchnic area as for as in-
cressing intestinal movements were concerned and
they believed that such a procedure was distinctly
dangerous because of its marked cardio-vascular
effects. However, when procaine hydrochloride was
used they concluded that splanchnic and spinal
analgesia were of definite value in relieving cases
of paralytic ileus, they believed that the effect
of the splanchnic analgesia on the motility of the
intestine was more effective than that of spinal
analgesia. They cautioned about the use of splan-
chnic analgesia stating that where there was a
peritonitic process the case should be carefully
considered, because the peritonitis might be converted
into a generalized one. These authors had used this
means of treating some clinical cases of paralytic
ileum and believed it was of distinct value in the
"so called paralytic or adynamic ileus where the
condition was due to inhibitory impulses supplied
the intestine by the sympathetic system."

Brown(68) reports the use of spinal analgesis
in cases of postoperative ileus. He gave three-
fifths the anesthetic dose of procaine intraspinally
and apparently "relieved all symptoms of ileus in three cases which previously appeared hopeless."

abd believed that the good results from blocking the splanchnics overbalanced the dangers in a severe case of postoperative ileus. The dangers he refers to were the wall in blood pressure associated with the giving of the procaine. Ochsner et. al. referred to in the previous paragraph stated that epherine or adrenaline, so frequently given with spinal anesthesia, must not be used when the procedure was being done to stimulate the gut as these drugs tend to inhibit intestinal motility and thus nullify the effect of the analgesia.

Barlett,(69) advocates the use of spinal analgesia in those cases for intestinal obstruction in which the diagnosis between the mechanical and functional constipation to be definitely made. He injects a spinal anesthesia, waits fifteen minutes, and if the bowels do not move during this time concludes that the obstruction is a mechanical and utilized the spinal anesthesia in operating for the mechanical obstruction. Ochsner(28) seriously questions the value of this procedure for making such a dif-
ferential diagnosis.

Methods of Decompression:

The possible methods of decompressing a distended bowel are represented by 1. stomach, duodenal and rectal intubation and 2. some operative procedure (enterostomy). We shall now consider the first of these two measures.

Gastric intubation has been used in the form of a gastric lavage since the beginning of abdominal surgery. Any surgeons believe that a prophylactic cleansing of the stomach should be made a routine matter at least in cases of general anesthesia, and habitually practice it. These authorities believe that thereby postoperative vomiting is minimized because the irritative action of the stomach contents is obviated. Cutting(4) gives a description of the method of postoperative gastric lavage. He states, "Usually the amount and character of the washings of a stomach as thus obtained is a revelation to one seeing them for the first time, and serve to convince many skeptical observers of the possible value of the procedure as a reoutine manipulation."
Although aspiration or lavage of the stomach both as a prophylactic measure and for continued postoperative nausea and vomiting has long been common practice among abdominal surgeons it was not until 1921, when Levin developed the catheter tipped nasal tube, that gastric and duodenal intubation came to play an important part in the postoperative treatment of surgical patients. Later Ward(70) described the use of constant suction in conjunction with the Levin duodenal tube. Although the application of these developments have been the use of constant suction with a Levin duodenal tube in decompressing certain types of acute mechanical intestinal obstruction, the procedure has also been employed postoperatively as a prophylactic and therapeutic measure in cases of postoperative paralytic ileus. Wagensteen(71) points out in this connection that the use of duodenal intubation postoperatively is a logical procedure if our concept of the mechanism and pathology of postoperative distention is correct. There being no sphincters between the phloric canal and the cecum one may readily demonstrate to one's satisfaction on the intact dog or in the human intestine
excised at necropsy in the presence of induced
distention of the intestine with either water or
air, that suction applied to one end is appreciated
in the same degree at the other. When a mixture of
fluid and gas is present, however, the problem
— well known to physcists, whether dealing with rigid
or elastic tubes comes into play. In the presence
of an established intestinal distention of a mixed
gaseous and fluid character, a slow decompression
with constantly applied suction is to be anticipated
even when the catheter projects beyond the pyloric
sphincter." He describes the method for the use of
this apparattus and mentions that after the tube is
introduced into the stomach it frequently finds
its way into the duodenum and he states that he
has found it advantageous to have extra holes cut
in the duodenal tube as far back as ten inches proximal
to the tip. The passage of the catheter into the
intestine, he states, has been found to be a very
desirable feature in that suction may be simultaneously
and continuously applied to both stomach and bowel.
He points out that one difficulty which can occur
is the engagement of the wall of the intestine or
stomach into the holes of the tube and stated that
he had found that about seventy-five cm of water suction represented the optimum value for the amount of suction to be employed. These authors recommended the employment of the naso-catheter suction-siphonage "for routine use after operations on the biliary tract and the stomach and after plastic and anastomotic types of operations on the intestine. It may also be employed with benefit in instances of established intestinal distention of an inhibitory (paralytic) character. Sed postoperatively they said "it is an effective method of increasing the patient's comfort and reducing the postoperative incidence of distention, nausea and vomiting. Its use also practically precludes the necessity of administering enemas in the early postoperative period." They reported the results of a series of cases in which the nasal suction-siphonage was employed. Their series included thirty-eight cases, although they had used it in over five hundred. In most instances, suction was begun as soon as the patient returned from the operating room and thereby so doing the occurrence of postoperative distention was almost entirely eliminated. The incidence of nausea and vomiting parallel each other closely and
was greater than the incidence of distention.

Many of the patients which had nausea and vomiting with the catheter suction, however, were nauseated only a few minutes or vomited only once, and others were completely relieved when the duodenal tube was readjusted. The length of the time required to employ the tube varied with the individual cases. Before removing the tube they would clamp it at intervals during the day and at the same time allow the patient to take oral fluids, in this way the ability of the patient to do without suction would be tested.

They stated that in their series of postoperative cases no attempt was made to intubate the tube into the duodenum. When suction was not commenced, however until distention was established, quicker decompression was achieved by introducing the tube into the duodenum.

In considering the indications for the use of the nasal suction-siphonage they point out that many patients undergo operations within the abdomen and experience little postoperative discomfort that would be relieved by suction, this factor, together with the slight discomfort caused by the patient might lead some to think that the merits of the procedure
caused to the patient might lead some to think that the merits of the procedure did not warrant its use routinely. They point out that altho nausea and vomiting can usually be relieved by suction after they occur, distention of the paretic intestine is more easily prevented than relieved after it becomes established. They used the method routinely after all operations on the biliary tract, the stomach and the intestine, after simple appendectomies and herniotomies it was used only if during the postoperative period the patient suffered unduly from distention, nausea or vomiting.

In the event that a nasal suction-siphonage is being employed either as a prophylactic or therapeutic measure, it at once becomes apparent that a considerable amount of fluids secreted from the stomach duodenum, liver and pancreas will be drawn off, the withdrawal of these fluids obviously introduces an aspect of treatment which becomes paramount and which must always be associated with the use of suction siphonage, and it is obvious that fluid replacements will have to be made to compensate for the aspirations. Wagensteen (71) permitted postoperative patients an oral intake of two thousand cc
of fluid per day and was of the opinion that large amounts of oral fluid would enhance the chloride loss. By quantitative determinations they found that when two thousand cc of oral fluid was given patients, approximately 1.5 gm of chloride expressed as sodium chloride would be aspirated by the duodenal tube. When four thousand cc of oral fluid was given the chloride loss was approximately 3.5 gm. They permitted any clear liquid by mouth. Milk or ice cream could not be given because they clotted in the stomach and stopped the suction apparatus. In addition to the oral intake of fluids a fairly generous amount of physiologic solutions of sodium chloride was given subcutaneously and 5 per cent dextrose in saline solution intravenously (from 2,500 to 4,000 cc). They stated that the best guide as to how much fluid should be given was the urine output. A daily twenty-four hour urine excretion of from eight hundred to one thousand cc indicated that the fluid intake was adequate. They stated further that dechlorination of the patient need not be feared if the urine output was adequate.

Stout(5) developed a system for the use of the nasal suction-siphonage based on water balance of the
gastro-intestinal tract and the tissues. He believed that from proper water exchange records which he kept that one could determine the severity of a case of ileus and the daily progress that was made toward recovery. Also he stated that one could determine when it was safe to administer liquid nourishment and to remove the duodenal tube routinely used.

He reported several cases in which the water exchange records had been kept in support of his conclusions. The system requires an understanding of a coordination of what he terms gastro-intestinal balance, tissue balance, parenteral intake, etc, and fluid balance the details of which will not be discussed here.

Sufficient to say that the method which he recommends offers possibilities in that it gives the observer a mathematical statement of the clinical course of the patient's progress, in terms of water balance. Bartlett (72) has worked out a similar arrangement on the basis of what he terms "pyloric Balance™.

The methods of both of these workers is worthy of consideration for one who has frequent application of the use of gastric or duodenal suction and their articles should be consulted for details.
Enterostomy.

Like the use of other procedures, the enterostomy has had its heyday in the treatment of paralytic ileus. Bonney was one of the first to advocate the enterostomy in the treatment of this condition. In 1916 he (73) having employed this method for six years stated; "that when postoperative paralytic obstructions of the intestine have advanced to the stage of faecal or short of faecal, intestinal vomiting, should be treated by jejunostomy." McKenna (74) recommended this form of treatment for the condition also. Van Beuren (75) made a statistical inquiry into the value of enterostomy for the treatment of acute ileus and could not discover definite, inc ontrovertable proof that enterostomy had lowered the mortality rate in this condition. The status of the enterostomy in the treatment of paralytic ileus, as summed up by Ochsner (28) is as follows: "in those cases in which transduodenal drainage has failed to decompress the intestine and in which adynamic ileus persists because of intramural strangulation caused by marked intestinal distention, further decompression is imperative. This can be accomplished by either single or multiple enterostomies."
Frequently a single enterostomy will fail to
accomplish the necessary decompression and because
in adynamic ileus the propulsive power of the gut
is lost, the decompression is limited to that par-
ticular loop of the gut drained by the enterostomy.
This frequently explains the failure to obtain relief
by enterostomy in adynamic ileus. In this type of
case satisfactory decompression can be obtained,
however, by several enterostomies. It must be
remembered, however, that an enterostomy is not a
panacea and that the most that can be expected
of it in cases of adynamic ileus is decompression
of the bowel, which will in turn prevent interference
with the blood supply to the gut musculature and thus
favor the return of intestinal movement. It should
be emphasized that enterostomy, even though probably
of value in late cases, preferably should be used
after the simple measures have failed, because
following prolonged and marked distention of the
intestine all decompressive procedures may be of no
value in reestablishing intestinal movement.
BIBLIOGRAPHY

1. Abel, A. B.
   Acetylcholine in Paralytic Ileus.

2. Nothnagel, Hermann
   Diseases of the Intestine and Peritoneum,
   English translation, W.B. Saunders & Co.
   Philadelphia, 1904.

3. McIver, M. A.
   Acute Intestinal Obstruction,

4. Cutting, R. A.
   Principles of Preoperative and Postoperative
   Treatment.

5. Stout, Gurn.
   The Pathological Physiology of Ileus as a Basis
   for Treatment.

6. Meltzer, S. J. and Auer, J.
   The Peristaltic Rush
   Am. J. Physiol. 20, 250-281, 1907.

   The movements and Innervation of the Small Intestine
   J. Physiol. 24: 110, 1899.

8. Cannon, W. B.
   The Movements of the Intestine Studied by Means
   of the Roentgen Rays.
   Am. J. Physiol. 6: 256-275, 1902.

9. Cannon, W. B.
   Peristalsis, Segmentation and the Myenteric Reflex.
   Am. J. Physiol. 30: 114, 1912.

10. Alvarez, W. C.

11. Alvarez, W. C., and Mahoney L. J.
    The Myogenic Nature of the Rhythmic Contractions
    of the Intestine.
    Am. J. Physiol. 58: 421-430, 1922.
12. Bayliss W. M. and Starling E. H.
Movements and Innervation of the Small Intestine.

13. Alvarez, W. C.
Bayliss and Starling's Law of the Intestine or
The Myenteric Reflex.
Am. J. Physiol. 69; 224-248, 1924.

14. Kantor, J. L. and Marks, J. A. A.
Study of Intestinal Flatulence.

15. McIver, M. A., Benedict, E. D., and Cline, J. W.
Postoperative Gaseous Distention of the Intestine
Experimental and Clinical Study.
Arch. of Surg. 13: 588, 1926.

16. Fries, A. J.
Intestinal Gases of Man.
Am. J. Physiol. 16; 488, 1906.

17. Dunn, A. D. and Thompson, W.
The Carbon Dioxide and Oxygen Content of Stomach
Gas in Normal Persons.

18. McIver, M. A. Redfield, A. C. and Benedict, E. B.
Gaseous Exchange between Blood and Lumen of Stomach
and Intestine.
Am. J. Physiol. 76: 92, 1926.

See bibliograph No. 4.
J. Physiol. 36: 283, 1905.

20. McIver, M. A.
Acute Dilatation of the Stomach Occurring under
General Anesthesia.

21. Dragstedt, L. R.
Blood Chemistry in Intestinal Obstruction.

22. Cannon, W. B. and Murphy, F. T.
The Movements of the Stomach and Intestine in
Some Surgical Conditions.
23. King, C. E.
   Studies on Intestinal Inhibitory Reflexes.
   Am. J. Physiol. 70: 183-193, 1924.

24. Engel, G. C.
   Post-operative Ileus and its Treatment

25. Bonney, Victor,
   The Functional Derangement of the Intestine that Follows Abdominal Operations.

26. Alvarez, W. C. and Hosoi, K.
   What Has Happened to the Unobstructed Bowel that Fails to Transport Fluids and Gas?

27. Dragstedt, C. A., Lang, V. G., and Millet, R. F.
   Relative Effects of Distention on Different Parts of the Intestine.
   Arch. Surg. 18: 2357, 1929.

28. Ochsner, A. and Gage, I. M.
   Adynamic Ileus.

29. Coller, F. A. and Maddock, W. G.
   Dehydration Attendant on Surgical Operations.

30. Rowntree, L. G.
   Water Balance of the Body.

31. Orr, T. G. and Haden R. L.

32. Gamble, J. L. and Ross S. G.
   Factors in Dehydration Following Pyloric Obstruction.
   J. Clinic. Investigation, I: 403-423, 1925.

33. Glass, S. J. and Wallace, H. S.
   J. A. M. A. 78: 24, 1922.
34. Gwathmey, J. F. and Hooper, C. W.
Preliminary Medication in General Anesthesia
with Reference to Margin of Safety and Post-
operative Lung Lesions.
Anesth and Analg. 7: 167, 1928.

35. Mitchell, W. E. M.
Preparation of Patients for Operation.

36. Alvarez, W. C.
Is the Purgation of Patients Before Operation
Justifiable?

37. Alvarez, W. C. and Taylor, F. B.
Changes in Rhythmici ty, Irritability and Tone in
the Purged Intestine.

38. Woodyatt, R. T. and Graham, E. A.

39. Crile, G. W.
Shock.

40. Plant, O. H. and Miller, G. H.
Effects of Morphine and Some other Opion Alkaloids
on Muscular Activity of Alimentary Canal; Action
on Small Intestine of Unesethetized Dog and Man.

41. Orr, T. G.
Action of Morphine on small intestine; Clinical
Application in Treatment.

42. Ochsner, A., Gage, I. W., and Cutting, R. A.
Effects of Morphine in Obstruction.

43. Ochsner, A.
Postoperative Treatment to Prevent Ileus.

44. Fine, J. and Levenson, W. S.
Effects of Food on Postoperative Distention.
Am. J. Surg. 21: 184, 1933.
45. Fine, J., Sears, J. B., and Banks., B.M.
   Effect of Oxygen Inhalation on Gaseous Distention
   of the Stomach and Small Intestine.
   Am. J. Digestive Diseases and Nutrition
   2: 361, 1935.

46. Alvarez, W. C.
   The Influence of Drugs on Intestinal Rhythmicity.
   Am. J. Physiol. 48: 554, 1918

47. Cross, D. G. T. K.
   The Action of Physostigmine and Pituitrin.
   Brit. M. J. 1: 9, 1924.

48. Martin, H. E. and Weiss, S.
   Physostigmine in Abdominal Distention.
   J. A. M. A. 84: 1407, 1925.

49. Martzloff, E.
   The Use of Eserin and Strychnine in Postoperative
   Abdominal Distention.

50. Moenninghoff, F. J.
   A Brief Consideration of Postoperative Gaseous
   Distention of the Abdomen with Suggestions for
   Prevention.
   J. Missouri M. Assoc. 5: 193, 1908.

51. Bell, Blair.
   The Pituitary Body and the Therapeutic Value of
   the Infundibular Extract in Shock, Uterine Atony
   and Intestinal Paresis.

52. Young, A. W.
   On Movements of the Isolated Small Intestine and the
   Action of Various Drugs and Extracts Upon them.
   Quart. J. Exper. Physiol. 8: 347, 1915.

53. Dixon, W. E.
   Pituitary Secretion.

54. Cross, D. G. T. K.
   Action of Physostigmine and Pituitrin; Action of
   These drugs Alone and Combined upon Isolated Human
   Vermiform Appendix; The Advantage of Their Combined
   Use in Postoperative Ileus.
   Brit. M. J. 1: 9, 1924.
55. Bayer, G. and Peter, L.
   Quoted from Butting's Biblio. No. 4.

56. Hopkins, A. H. and Pancoast, H. K.
   Action of Pituitrin.

57. Marinus, C. J. and Atwell, W. J.
   Comparison of the Activity of Extracts of the Pars
   Tuberalis with Extracts of other Regions of the Ox
   Pituitary.
   Am. J. Physiol. 47: 76, 1918.

58. McIntosh C. A. and Owings, J. C.
   The Effects of Solutions of Pituitary and Various
   Drugs on the Movements of the Small Intestine
   During Simple Mechanical Obstruction.

59. Ochsner, A., Gage, I. M. and Cutting, R. A.
   The Value of Drugs in the Relief of Ileus.

60. Hughson W. and Scarff, J. E.
   The Influence of Intravenous NaCl on Intestinal
   Absorption and Peristalsis.

61. Ross, J. W.
   Hypertonic Saline in Adynamic Ileus.

62. Coleman, E. P.
   Further Observations on Use of Hypertonic Saline
   Solutions in Acute Intestinal Obstruction.
   Anesth and Analg. 6: 310, 1927.

63. Ochsner, A., Gage, I. M. and Cutting, R. A.
   Treatment of Experimental Ileus by Hypertonic
   Solutions.

64. Ochsner, A. Gage, I. M., and Cutting, R. A.
   The Influence of Hypertonic Salt Solution on
   the Motility of the Normal and Obstructed Intestine.
   Arch. Surg. 27: 742, 1933.

65. Johnson, S. E.
   Experimental Degeneration of the Extrinsic Nerves
   of the Small Intestine in Relation to the
   Structure of the Myenteric Plexus.
66. Ochsner, A., Gage, I. M., and Cutting, H. A.
   Comparative Value of Spinal and Splanchnic Analgesia
   in the Treatment of Experimental Ileus.
   Arch Surg. 20: 802, 1930.

67. Ochsner, A., Gage, I. M., and Cutting, H. A.
   Treatment of Ileus with Splanchnic Anesthesia.

68. Brown, G. G.
   Treatment of Postoperative Ileus with Spinal
   Analgesia.

   An Indication for Early Operation in Intestinal
   Obstruction.

70. Ward, Robertson.
   An Apparatus for Continuous Gastric or Duodenal
   Lavage.
   J. A. M. A. 84: 1114, 1925.

71. Paine, J. R. Carlson, H. A. and Wagensteen, O. H.
   Postoperative Control of Distention, Nausea and
   Vomiting, Clinical Study with Reference to Employment
   of Narcotics, Cathartics and Nasal
   Catheter suction-Siphonage.

   The Concept of Pyloric Balance.

73. Bonney, Victor.
   Fecal and Intestinal Vomiting and Jejunostomy.

74. McKenna, —
   Drainage of Upper Intestinal Loops for Relief of
   Ileus.

75. Van Beuren, F. T. and Smith, E. S.
   The Status of Enterostomy in the Treatment of Acute
   Ileus.
   Arch Surg. 15: 288, 1927.