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Etiology and treatment of post-operative gas pains

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Introduction

Postoperative gas pains represent, unquestionably, the most common complication of major surgical procedures. Yet their importance does not seem to be universally appreciated, nor have they been accorded the thoughtful consideration which their frequency and significance warrant. This may be explained by the fact that they are seldom serious in their consequences and are usually transitory in character, rarely lasting beyond the fifth postoperative day. Few surgeons deny the sense of relief which accompanies the termination of the "gas pain" period, and all will admit that it is, disturbingly often the one unpleasant memory which the patient associates with his surgical experience. The patient's dread of abdominal surgery is deeply tinctured by fear of "gas pains", which are familiar even to the general public, as the prominent symptom of a distressing, distention ridden postoperative course.

It is a matter of common knowledge that an extensive operative procedure may be followed by a smooth convalescence absolutely devoid of "gas pains", while a simple, uncomplicated appendectomy may rise to "gas pains" of such severity as to cause the surgeon apprehension and even alarm. This variability in the appearance of "gas pains" has caused a considerable speculation concerning the factors which might play a role in their production. In some instances, certain factors have been suggested as the result of laboratory experimentation as well as clinical observation, while in other instances the causative factors have been adduced simply as impressions based upon individual experiences.

It was in the summer of 1938 when I became most interested in the study of "gas pains". It began with an operation for an inguinal hernia which was performed on me at the Mayo Clinic. I was hospitalized at

4:00 P.M. Sunday afternoon and was given an enema and put on a liquid diet. Monday morning I had no breakfast but another enema which was very irritating and made me very uncomfortable. I was given preoperative medication (luminal) and at 11:00 A.M. I was operated under spinal anesthesia. On returning to my room, still under the effect of anesthesia, I felt very well. After sleeping for nearly 10 hours I awoke with some discomfort in my abdomen. I had taken no food but the interen administered 1000 cc of soline in glucose solution introvenously. I slept well until the following morning but felt very miserable on awakening. My abdomen was distended and I experienced my first "gas pains". They made me restless and at times I felt as though I wouldn't dare take a deep breath. Morphine was administered and gave considerable relief from pain, but the distention remained. As soon as the effect of the morphine wore off (30-60 minutes) the pain gradually returned and appeared to be considerably increased. An enema was given with poor results and no relief. This was later followed by insertion of a rectal tube which offered considerable relief. I had eaten much solid food and felt surprisingly well. The rectal tube was still in place. On the end of the third day the rectal tube was removed and more distention and pain occurred.

It was here that I became interested in having two questions answered: Why did I suffer gas pains when my peritoneal cavity proper was not entered during the operation? Why is there no drug used to aid the intestine in eliminating the postoperative distention and preventing gas pains?

The two days I spent combating "gas pains" are well imprinted on my mind and they were by far the most distressing period in my postoperative convalescence.

It is not surprising, therefore, that a wide variety of drugs are being tried for the relief of "gas pains". Many mechanical devices and procedures have been employed to combat this unwelcomed postoperative complication.

The methods advocated in different clinics for its prevention and treatment are so varied in character and often in such striking contradiction to each other that one is forced to the conclusion that there is no general agreement as to the underlying physiologic process. These processes are complex and the amount of experimental work bearing directly on them is small. Some of the more fundamental features of the problem are undoubtedly concerned with the disturbances of motor activity of the gastro-intestinal tract following injury.

Today operations have been made remarkably safe. The next thing is to reduce the amount of discomfort attendant on them. If by any procedure surgeons can eliminate postoperative vomiting and postoperative pain they will be doing something worth while, something which will rebound to their credit individually and collectively.

Definition and Clinical Picture

Shuman & Misselt (58) define postoperative "gas pains" as, "a motionless distention of the intestines due to paralysis of the muscular tunic of the bowel, with no mechanical obstruction present."

Levis & Axelman (36) give an identical definition "postoperative intestinal atony is a paralysis of the muscular tunic of the bowel attended by a moderate to extreme distention of part or all of the intestinal tract in the absence of any obstructive lesson."

The clinical picture of postoperative "gas pains" is well known, the ballooning belly attended by interference with circulation, toxemia, respiratory embarrassment and pain. Little difficulty is experienced in the diagnosis of the unusual mild form of "gas pains" following any abdominal operations. According to Duval (20), the complication evolves in three stages: the first as aggressive stage, evolves in 24 to 36 hours and is characterized by pains, not very severe but tenacious, oliguria, discomfort experienced with every movement, bloating, nausea, an abnormal sensation of thirst, all expressing a disturbance of the humoral equilibrium due to hyperpolypeptidemia. The second stage of clinical improvement evolves in the next 24-48 hours, associated with diminuation of the polypeptidemia and accentuation of chloremia. The third or variable stage is evolution toward recovery anticipated by a further increase in chloremia and decrease in hyperpolypeptidemia. The malaise is succeeded by restlessness, depression and headaches, the nausea by vomiting, gastric and intestinal distention, oliguria or complete retention, and a peritoneal syndrome of hypotension, tochycardia and cyanosis run a parallel course with dyspnea and collapse.

Ochsner and Gage (44) state that the pain is more apt to be continuous, of a dull aching or boring character. The patient, at first, may not appear

very ill. Depending upon the extent of the involvement, there result varying degrees of abdominal distention. In a number of cases, due to relaxation of the pyloric sphinter, abnormal regurgitation of intestinal contents occur into the stomach. There is each of normal caudal propellation of intestinal contents, in fact there may be actual reversal of peristalsis and fecal vomiting.

Auscultation of the abdomen in postoperative "gas pains" there is absence of peristalsis and peristaltic sounds.

Alvarex (5) believes that much of the pain produced by distention of the bowel appears to be due to tension on the root of the mesentery. Pain is produced in a hollow organ when powerful contractions struggle to force material past a kink in the intestine, or it may be produced also by rapid distention.

Bonney (14) suggests that the abdominal cavity is in reality divided into many small compartments, the divisions between which are various points where the mucosa is in contact either on account of contraction of circular fibers or the pressure of the adjacent coils. The intestinal gas therefore does not constitute a single gaseous column but a series of columns, which is why the intestine does not collapse throughout its length when opened. Each column of gas is bounded not only by the wall of its compartment, but by the coils of intestines that surround it. If the amount of gas in any particular column is quickly increased the pressure in that compartment will rise and adjacent compartments will be compressed until the pressure in them rises to somewhere about that in the first compartment. Local distention, therefore, of any segment of the intestine unless compensated for by withdrawal of gas elsewhere, compresses and rises the pressure in neighboring coils, so that additional force is required to pass anything into them.

It is surmised that the colic often seen in pastoperative "gas pains" is due to the efforts of intestinal muscle to force gas and fluid into compressed coils.

Difficulty arises when one tries to explain the origin of pain from viscera which ordinarily seem practically insensative to stimuli that experience has taught us would produce pain on body surfaces. Lennander attempted to explain this by suggesting that painful impulses from diseased viscera reached the patients consciousness through the medium of parietal peritoneum and its subserous layer over the cerebrospinal sensory nerves. Ross suggested that internal organs gave rise to two types of pain; true splanchvic pain which was felt in the organ from which the offerent impulse arose, and an associated pain, which, he believed, was felt in the cerebro spinal nerves of the body wall which are connected with the same segments of the spinal cord as the affected splanchnic nerves.

Alvarez (6) comes to the conclusion that stimuli reaching involuntary muscles by way of nerves do not act directly, but by way of chemical substances which are found at the ends of the nerves. The substance spreads out into the muscle causing it either to contract or relax, depending on the chemical state of the muscle at the time when the acetylcholive and epinephrine or whatever it is arrives. The clinican will begin to wonder, with these conceptions, what mechanisms back of some of the queer disturbances as gas pains and failure of peristalsis which he sees postoperatively. If in these cases a sensative sympathetic mechanism should yield to control a hardy long pathed one, the resultant systole might well produce colic, gas pains and a type of activity which does not help to pass onward to contents of the bowel. One can imagine adjacent segments contracting in such a way as to distend the segment between them and produce pain.

In diagnosis of postoperative "gas pains" care must be taken to differentiate it from acute abdominal obstruction. The more severe forms of distention with vomiting are similar to mechanical forms of ileus. In the differentiation of intestinal obstruction and postoperative gas pains, Sear Louis (54) believes the time factor is most important. Paralysis is an early postoperative complication, mechanical obstruction usually late sequele. In the former, the pain is constant and of a dull boring character. In the latter condition it is also characteristic of mechanical ileus and when observed is pathognomonic. The absence of borborygmi in the paralytic form and finally the roentgenographic findings should furnish sufficient evidence to differentiate these conditions. Hannet (27) suggested spinal anesthesia as a means of differentiation.

Etiology

Preoperative Purgation

During the last decades, rapid progress has been made in all fields of modern medicine. Many traditions based on the experiences of the early doctors had to fall before the logic and research of modern investigation. There is, nevertheless, a tendency to put tradition above new ideas because the valuable experiences of the earlier observers have apparently proved efficacious for one or another period of medicine. Furthermore, the medical student who has received in his early training didactic teaching which offers many medical traditions in the form of strict rules, becomes so deeply impressed that it seems to him that medical sacrilege is committed if the teachings of his school days are attacked.

One of the best examples of this is the old custom of purging and dieting, in other words, carefully "preparing" patients before operations. The underlying idea of this habit developed in the dark ages of medicine. Alvarez in a review of the history pertaining to this subject, traces the development of the custom of purging back to the days when humoral pathology dominated the minds of all medical men. Humoral pathology fell, but the custom of purging before operations remained and became the iron clad rule in surgery. Many protests have been made but have been without results. Many of these protests are buried in articles pertaining to other subjects and are, therefore, hard to uncover. Among the more recent observers on the clinical side of the question, Harris (29) warned against purging in acute abdominal infection but neglected to speak about purging in general. Walker (63) in 1906 reported that he had not used purgation in his preoperative preparation for more than two years, and that he was convinced that his patients suffered less with tympany and recovered more quickly. Moore (43) states that

a surgeon would not operate a patient weakened by diarrhea, but that a strong cathartic and enemas are given preoperatively.

Quain (51) commented on the less stormy convalesence of patients who had not been purged. Those of his patients carefully prepared developed the worst "gas pains". Bloodgood (12) noticed that purging before operation interfered with the normal tone of the intestine and stopped giving cathartics 48 hours before operation. He had less trouble with intestinal paresis and "gas pains".

Cunningham (16) in making a comparative study of this subject, was forcibly struck with the fact that he had less distention and gas pains in his series of cases operated at the Robert B. Green Memorial Hospital than in his private cases. After careful investigation and observation, he reached the following conclusions: First, that his charity patients were in a hospital for a longer period prior to operation than in his cases in private practice; second, the former also received a purgative soon after entering the hospital, thereby avoiding the usual doses of castor oil on the night prior to operation but on the other hand, were kept on a light diet with lots of fluids and then an enema at night and morning before operation. He believes that the small intestine empties itself in from seven to nine hours and the colon can be thoroughly cleansed with an enema on the morning of operation.

Emge (21) finds that in many patients, especially those that have not been purged, the bowel will perform its function normally as soon as solid material finds its way into the bowel. In purged patients there is a much longer period before the bowel will function normally and aid must be given to restore this normal function.

In a series of cases from Barnes Hospital, reported by O'Keefe (46) when castor oil was given in preparation for operation, the percentage of patients suffering from gas pains increased to 62.5 per cent, while in those cases that received the same preparatory treatment that he has been using, the percentage was reduced to 9.6 percent.

Ottenheimers (46) 400 cases were placed on a non-purgation pre-operative routine the night before operation. Emergency cases, as a rule were given no enema, but a record was kept as to when the bowels had moved last. If the patient had entered the hospital the day before operation, an enema was given the afternoon before operation in most cases. In some cases an enema was given on the morning of operation. With this non-purgation routine postoperative gas pains were less common in those cases whose bowels had moved either naturally or by enema the day of operation.

Emge (21) made a comparison of 50 purged and 50 unpurged patients. Purging consisted of one ounce of castor oil at night before operation and a liquid diet was prescribed with no breakfast and an enema of soap suds early in the morning at 6:00 A.M. on the day of operation. The unpurged patients received only an enema at night before operation and one in the morning of operation. The results are very striking as shown in the table:

	With Purge		No Purge	
	No. of Cases	%	No. of Cases	%
Severe Gas Pains	11	22	1	2
Mild Gas Pains	15	30	2	4
Cramps	11	22	14	28
No Gas Pains	13	26	33	66

It has also been shown by experiments on animals that peroperative catharsis is harmful rather than beneficial. Alvarez and Taylor (61) purged a number of animals and then compared excised segments of small

intestines from these animals with segments from the normal animal. They found the animals to be apathetic and sick looking, that the excised segments of small intestine of these animals showed a rapid fatigue and they were less sensitive to drugs. They found further that the majority of purged animals showed increased intestinal gas and very often a congestion of the mesenteric circulation. Most important of all, there was an upset in the gradient of muscle forces from the duodenum to the ileum. It is the intestinal gradient which Alvarez (4) has shown to be so essential to the even progress of food and gas toward the anus. This is in agreement with other laboratory workers who have studied the problem of flatulence. Schmidt (56) 1909 pointed out that congestion of abdominal circulation leads to the collection of gas into the intestine and results in distention and "gas pains".

Evidence of Emergency Operations

Further proof of the harmfulness and needlessness of "intestinal" purgation can be obtained from the experience of surgeons with emergency operations. Nobody will deny that the woman with acute, a tubal pregnancy or a cesarean section will usually recover from the operation with little abdominal distress besides that occasioned by wounds. On the other hand, the "carefully prepared" patient who has been operated on for chronic appendicitis or who undergoes an exploratory laporatomy will often be troubled with most distressing "gas pains" and distention. In spite of all these observations, peroperative purging is still being practiced by many who follow simple tradition. Emge (21) states that the old argument, that a non-prepared bowel does not pack off well in laporatomy, is faulty because the bowel in emergency cases packs off very nicely. Experimental animals (never purged) never give difficulty with distention of bowel into the incision. These animals are very infrequently found to be distended and suffering from greatly distended abdomens.

Surgical Trauma

Regardless of which cause is ascribed as being productive of post-operative intestinal atony, it is reasonable to state that this cause in most instances, is a direct or indirect sequel of surgical interference. Many writers feel that the appearance of postoperative intestinal atony is in a sense an indictment of the surgeon, and while it cannot be denied that poor surgical technique and unnecessary handling of abdominal viscera increases the degree of intestinal atony, the appearance of this entity is not indicative of poor surgical technique.

Practically every laporotomy has some degree of distention due to postoperative intestinal atony. The importance the condition assumes is in direct proportion to the degree of distention and the discomfort suffered by the patient. (36)

Ochsner to Gage (44) also believe that every patient who has a laporotomy has for varying periods of time, usually from 6 to 24 hours postoperatively, a functional inactivity of the gastrointestinal tract.

Ottenheimer stresses avoidence of excessive manipulation of the intestine and the care with which gauze packs are used. He also warns against any act which might temporarily interfere with the circulation of any part of the intestinal tract.

It is difficult to estimate the amount or degree of trauma done during an operation. Operations in which there is relaxation of the abdomen, in which exposure of the operative field could be made easily and gently, and in which the intestines had been manipulated not at all or to only a slight degree result in a short uncomplicated postoperative course. Such an operation was graded by Ottenheimer as +1 trauma. Gradings up to 4 + were made according to the degree of trauma. His statistics show that

greater trauma increased the incidence of gas pains as well as the severity.

Howard Gray (26) states, "I can state that I am convinced that trauma is perhaps one of the most important etiologic factors in postoperative gas pains. Unquestionably, rough handling of the intra-abdominal structures at the time of operation is responsible to a marked degree for gas pains; the importance of avoiding unnecessary manipulation cannot be over estimated. In many instances low grade peritonitis which ensues either from low grade handling or from some definite infectious process, and even a chemical irritation, may be incriminated also. In fact, there are those who will not admit that paralytic ileus ever occurs in the absence of peritonitis. There is a tremendous controversy as to just what constitutes peritonitis and the question probably will remain unanswered. Meticulous care in the handling of tissues and in avoiding soiling of the hands, I am sure will reduce incidence of miserable postoperative complications."

Of major importance in the prevention of postoperative intestinal disturbances is taking care not to subject any traction on the mesentery. The use of gauze pads and tapes reduces this to a minimum. (54) Keene of the University of Pennsylvania makes use of a rubber dam envelope into which is placed an absorbent gauze lining. The envelope is 16x10 inches and is open only on one side, thus permitting the introduction and removal of the gauze lining. The smooth surface, unlike a gauze pack minimizes friction keeps the intestines completely from the operative field. Further care is exercised by the cautious and minimal use of self retaining retractors, and also by removal of clots and by scrupulous hemastosis. Mass ligatures which encourage the formation of devitalized tissue and obviously furnish continued stimulation of the splanchnic nerves are avoided. At the termination of the operation before the peritoneal closure is made Keene (54) instills

into the rectum 500 to 750 cc of warm saline solution. This has a two fold purpose of supplying water lost during anesthesia and also in showing the integrity of the rectum and sigmoid. All his patients have a very smooth and short convalescence.

Bessell (11) has offered his rubber pads as a means of lessening trauma and claims a 50% reduction of postoperative vomiting through this method, due to decrease in intestinal irritation.

Sar Louis (54) in his discussion believes the immediate cause of motor disturbances of the intestine to be irritation of the splanchnic nerves during operation. While there is no scientific proof, clinical observation yields the impression that lesser irritation produces increased peristaltic activity, whereas greater or more prolonged stimulation produces paralysis of intestinal movement. Stimulation may be mechanical or chemical and may at times be reflex. A probable example of reflex vagus stimulation is the rather frequent occurrence of gas pains following prostatectomy. Mechanical stimuli are undoubtedly set up by preoperative purge and trauma to the peritoneum during operation. Numerous investigators have proved that peritoneal irritation is followed by loss of intestinal peristalsis. The chief chemical irritants are hemorrhage, devitalized tissue and the products of infection. As a result of intestinal stasis, gases and toxic liquid materials containing histamine like substances accumulate. These give rise to increased splanchnic stimulation and probably also to diminished circulation in the distended loops.

Cannon and Murphy (15) in their experimental work delt with retarded intestinal mobility following various forms of injury and they distingushed between direct injury to the local mechanism in the wall of the intestine and other injuries that cause a reflex disturbance through the splanchnic

nerves. They believe that paralysis of the intestine does not per se cause such distention and the actual balloning is brought about by positive pressure of gas within the lumen.

Location of Operation

Cutting (17) states distention probably occurs more frequently and typically after operations upon the biliary tract, less frequently after operations in the pelvis and still less frequently following operations on the gastro intestinal tract. Bonney (14) states that the incisional site has an influence. Incisions situated above the umbelecus, or well out to the side of the abdomen, are least apt to be followed by gas pains than those situated below it or in the midline. A still greater immunity attends operations where the incisions open an annex of the peritoneal cavity as, for instance, inguinal and femoral herniatomy, vaginal hysterectomy or accidental opening of the peritoneum through a loin incision. Sar Louis (54) has noted that great abdominal distention may follow retroperitoneal nephrectomy and conditions involving the posterior retroperitoneal tissue, like hemorrhage in that situation, although in neigher instance has the peritoneal cavity been opened. Moreover, it not infrequently occurs after prostatectomy and is also seen in pregnancy and in terminal stages in pneumonia.

Gray (26) believes that the remote operations cause gas pains and distention because of the complex neurological hookup. He states, "Undoubtedly, there are innumerable other factors many of which are neurogenic in origin and in all probability the latter account for tremendous bloating associated with the distress that follows operative procedures on the kidney or ureter when the peritoneal cavity has not been opened. There is such a delicate neurological hookup particularly in the retroperitoneal

areas that a dynamic ileus quite frequently occurs, and may be most distressing. This may also account for ileus which is sometimes associated with such procedures as herniorrhaphy in which the gut is not handled."

Bonney (14) and Cunningham (16) also make special note on occurrence of postoperative gas pains after cesarean section. This, no doubt, can be attributed to the intestinal irritation as is set up through the emptying of the uterine contents, the direct trauma to the pelvic organs and, perhaps, to the relief of abdominal pressure.

Septic Surgery

The advent and extent of the gas pains have further no certain dependence on whether the operation area be septic at the time of operation or not septic. If in a septic case the abdomen is distended before the operation it will be distended afterward, but the distention does not necessarily increase, and if there is no distention before the operation it does not necessarily appear afterward. One would imagine, other things being equal, septic cases would exhibit much more postoperative flatulence than cases not septic, but if preoperative distention, which is continued after the operation, be excluded, and attention only be postoperative increase in intestinal gas, the difference between the two classes of cases is not great. Everyone has seen great distention follow a clean operation and a perfectly flat abdomen remain after an infected one (14).

Duration of Operation

Despite the fact that there has been a definite trand away from the rapid and spectacular, toward slow and gentle surgery, the majority of writers still feel that long operations contribute generously to stormy

convalescence and show a higher incidence of postoperative distention and "gas pains". Obviously there is an implication here that the more protracted the operation, the greater the degree of intra-abdominal trauma, the larger the exposure, the larger the volume of anesthesia administered.

Cunningham (16) believes that the time consumed in operating largely governs the postoperative course, so the shorter the better. He, however, warns not to sacrifice skillfulness for a time record. Loops of intestines should not be compressed under packing or under a retractor for any period of time thus injurying the nerve and blood sypply and interfering with its normal rhythmic peristalsis.

OKeefe (46) advocates quick neat work, but care should never be substituted for speed.

Anesthesia

The part anesthesia plays in the etiology of postoperative gas pains has been discussed by many writers. OKeefe (46) states, "I can not agree with the majority of writers as to the importance of ether in the cause of gas pains. It is undoubtedly a contributing cause, but it certainly has a transitory effect." Potter and Meuller (50) mention the anesthetic as a factor contributing to postoperative distention. Cunningham (16) believes that anesthesia must be considered as one of the many factors involved in the causation of postoperative distention. Whether the anesthetic is improperly or skillfully administered plays an important role. Ottenheimer (49) from 400 cases, found that the greatest percentage of gas paind (72%) occurred in cases observed that in cases in which avertin and ether were used, there was the highest percentage of severe gas pains. The next highest percentage of gas pains occurred

in cases in which spinal anesthesia were used. There is a current impression that gas pains are less common after spinal anesthesia than after inhalation anesthesia. This is very true and Asteriade (8) and Markowitz and Campbell (38) use spinal anesthesia as successful treatment for severe gas pains.

Ottenheimer (49) finds that postoperative gas pains may be just as common after the use of local or regional anesthesia as after general anesthesia.

Cutting (17) believes splanchuric and spinal anesthesia to be followed by a minimum of distention and gas pains. Splanchnic block, which is common to both these forms of analgesia prevents the delivery of inhibitory impulses to much of the intestinal musculature. The result is that paralysis of the intestine is reduced to a minimum. The tonicity of the intestinal wall also being largely preserved and intestinal movements tending to persist, gas does not become imprisoned and thus tends to be passed on and expelled. Under conditions of general anesthesia, the intestinal wall tends to become maximally paralyzed and in addition, the nature of the process of induction and reaction from anesthesia is such that air swallowing is greatly facilitated. General anesthesia, however, presents many general advantages which are usually accepted as outweighing such minor disadvantages as has been discussed.

O'Keefe (46) places very little emphasis on anesthesia as a cause of gas pains. He believes that pain, fear, nervousness play a greater part in the cause than does the effect of anesthesia.

The Gas

Since the gas is the agent causing distention it is imperative that its source, and make up be thoroughly studied. Bonney (14) states that the gases within the stomach and intestines are derived from three sources: (1) air taken into the stomach in the act of swallowing. (2) diffusion through the gastric and intestinal walls of gases in solution in the blood and (3) chemical changes in the intra-intestinal matter. The proportions normally contributed from these three sources to the total gas content is unknown, but they are probably variable. Experiments have shown that the quantity of air taken into the stomach during swallowing was not only definite, but that it was greatest when deglutition took place with the individual lying down. This was tested by McIver et al (41) in the following manner: A patient was still under ether, a small stomach tube of the type was passed into the stomach through the nares. The gaseous contents of the stomach then drawn off by means of a syringe: the tube was left in position for 24 to 48 hours, and the gastric contents aspirated twice daily. The average amount of gas drawn off at the first aspiration was 145 cc, the largest 600 cc. In certain cases, in addition to the gas present, there was an accumulation of fluid, the largest amount found being 480 cc, the usual amount was usually less.

Further proof of swallowed air was given by Alvarez (2) who noticed, during the war, many soldiers who were injured by mustard gas, developed severe gastritis and enteritis. It is possible that some of the gas taken by the lungs was excreted from the blood because some of these men had inflammation also of the lining of the gall bladder.

McIver (41) watched swallowing movements in patients during the early stages of anesthetization. In three of the cases observed, 115 - 67 - 54 swallowing movements respectively were noted while the patients were being anesthetized. Again it is a matter of common observation that great dryness of the mucous membrane of the mouth and pharynx is one of the after effects of ether, and that many patients make more effort to relieve this dryness by swallowing motions which carry air into the stomach. It was also observed that many patients following operation complained of gas in the stomach, which they often attempt to relieve by belching, and undoubtedly more air was swallowed in an attempt to relieve the gastric distress. A certain amount of air is carried into the stomach at each swallowing motion when liquids are taken, and the exclusively liquid diet given postoperatively must be responsible for a considerable intake of air.

Excretion of Gas into the Bowel

Woodyatt and Graham (66) inflated dog stomachs with gas and five minutes later withdrew samples for analysis. They found that a certain amount of Carbon Dioxide had been added to it. Sometimes the tension of this gas in the stomach was higher than that in the blood, suggesting strongly that active secretion had taken place. Large amounts of nitrogen that diffuse into the bowel are of interest because they do not readily pass backward again, and have to be carried to the anus and expelled as flatus. McIver and his associates (41) have demonstrated that if a loop of bowel is distended, Carbon Dioside passes from the blood into the intestinal lumen. As a result of increased intestinal pressure and early compression of venous return from the bowel, there occurs within the wall of the intestine edema and even infarction. At this point there is an enormous accumulation of gas in the bowel.

The contribution normally made by intra-intestinal chemical action is again not known, but the neutralization of the acid contents of the stomach must furnish a very definite quota, as also must the action of bacteria on certain substances, such as cellulose. (14)

Alvarez (3) states that it is questionable how much gas in distention is due to an increase in the amount of fermentation. Food passes too quickly through the stomach and there is little or no fermentation or putrefaction in the small intestine because at least in the jejunum, the chyme is fairly sterile and traveling too fast toward the colon. The one place in which fermentation and putrefaction of food residues can be looked for is in the right half of the colon where there is necessary stagnation.

Numerous investigators have proved that gases are both diffused through and absorbed into the intestinal wall, the relation between diffusion and absorption being such that a balance is maintained between the partial gas pressure of any particular gas in the lumen and the tension in the blood. The normal average pressure of gas within the intestine has been variously estimated, some observers stating it is above that of atmospheric pressure and some below. During surgical anesthesia the intestines fall away when the peritoneal cavity is open indicating that the intra-abdominal pressure is less. In distention there is gas pressure as seen by stretching of the abdominal wall. The presence of this pressure would be proved by observing that when, under full anesthesia, the abdominal cavity was opened the intestines not merely protruded but expanded after they protruded. All surgeons of experience have seen this phenomenon, and it shows that the adoptive power of the intestinal and abdominal walls is far greater than commonly supposed. The pressure of the intestines as a whole could not rise greatly for any length of time above atmospheric pressure, for such a pressure would stop the circulation through the abdominal veins. (14)

Removal of the Gas from the Bowel

Sar Louis (54) states that the gas in the bowel is removed by diffusion through the vessel wall into the blood stream and through the intestinal canal by painless peristaltic waves which consist of a ring of contraction preceded by a ring of relaxation.

Since the absorption of intestinal gases by the blood stream is such an important method of elimination it appears obvious that interference with the splanchnic circulation would upset the process and have serious consequences. McIver and his associates (41) tied the portal vein of a rabbit and found decreased absorption of Carbon Dioxide and distention of the gut. If the superior mesenteric artery is tied there is even greater distention. Tied off loops of the colon do not result in distention unless the circulation is disturbed. The small bowel absorbs gas more efficiently than does the colon partly on account of its corrugated surface, partly on account of its circulation is so much better. (3) Graham (25) believes that any circulatory disturbance in distention is due at least in part to inhibition of the pendulum movements of the intestine. Absorption occurs when the pressure of any gas in the lumen exceeds its tension in the blood, but the amount absorbed depends upon the rate at which the blood can carry it away. Peristaltic movements are also very valuable in helping greater absorption of gas by spreading it through the entire intestine and exposing it to a greater surface. (14) Baker and Andrus (9) find that there is also the factor of pulmonary compression due to the elevated diaphram from distention, and this may prevent the proper or sufficient oxygenization of the blood and reduce its gas elimination properties.

Sar Louis (54) looks upon diminished circulation of the intestine as a protective mechanism in that it retards absorption of toxic materials, but it deprives the body of important fluids, especially inorganic salts. He

attributes the cause of death in intestinal distention to alkalosis and absorption of toxins.

McIver and associates (41) did extensive experimental work to determine how the bowel functioned and how it was controlled in removing gas from the body per anus. From 60 to 90 cc. of air was injected into the stomach, causing a moderate degree of distention. Vigorous peristaltic waves were usually set up following the air injection. In certain experimentsthese continued for several hours without the passage of gas from the stomach into the intestine. From time to time rhythmic activity of the small intestine and colon was observed. In other experiments, after a short period of gastric activity the small intestine and colon became distended, the stomach decreasing in size as the gas was passed into the lower intestinal tract. It is thus evident that the stomach is capable of passing gas into the lower intestinal tract. Following section of both splanchnic and vagi nerves, the motor activity of the stomach and intestinal tract was increased. Under this condition the gas was invaribly passed from the stomach into the intestinal tract. Stimulation of both right and left vagi in the neck carried out with the stomach distended by gas, resulted in great motor activity of the stomach and small intestine, but in no case was any gas observed to pass from the stomach into the intestine.this result was expected, since increased tone and contractions of the pylorous and duodenum would act as barriers to the passage of gas downward. When strong stimulation was applied to the splanchnics, major and minor, of the left side just beyond the entrance into the abdominal cavity, increased tone in the stomach and increase in peristalic waves were noted in a number of cases. Under these conditions gas was passed down into the duodenum. Since this result was not abolished by cutting the splanchnics on the opposite side, and since the same result was

obtained when stimulation was applied to the proximal end of the cut splanchnic, it would appear to be a reflex phenomenon transmitted through the vagi. When stimulation was applied to the distal end of the cut splanchnic, the typical inhibition of the movements of the stomach and intestine and the blanching due to constriction of the blood vessels, were noted. In certain cases during increased activity following the period of inhibition gas was passed down. It is interesting that offerent impulses passing by way of splanchnics are effective in causing passage of gas from the stomach into the lower intestinal tract.

Analysis of the gas withdrawn from the stomach and intestines under normal circumstances and after abdominal operations shows a mixture which, broadly speaking resembles vitiated atmospheric air. Considerable variations but on the average, Nitrogen forms the largest component, while Carbon Dioxide and Oxygen are sparse as compared with air. In addition varying quantities of Hydrogen and Methane and Hydrogen Sulphide are sometimes present. (14)

Gas Pains Without Gas

In an effort to determine the amount of gas in the intestines of patients suffering from post operative gas pains Ferreira (23) made roentgenograms of nine abdomens. The roentgenograms were made when the pain was at its worst and again a few days later when it was gone. Strange to say, in none of the cases (9 cases) did the films, made at the time of the pain, show much gas in the bowel. It is conceivable that the pain is due to the bowel's contracting in an abnormal way on bubbles of gas, but it is obvious that it is not regularly due to the presence of large amounts of gas. This is not surprising in view of the fact that at times some persons can be badly bloated without experiencing any pain, whereas at other times when they are not distended, they will have pain which is relieved as soon as a little flatus begins to pass.

Obviously a study of only nine cases cannot settle anything, but because the evidence all points in the same direction, it seems worthy of note.

Treatment

Evemas and Rectal Tubes

Before considering the treatment of postoperative "gas pains" it would be well to review the normal mechanism of bowel activity. It is the paralysis of the bowel and loss of its activity that is the main cause of postoperative distention and "gas pains" Be the etrology what it may, every abdominal operation is usually accompanied by an inhibition of the normal peristaltic motions. The extent of the inhibition varies in a greater or less degree and is never considered serious unless over distention occurs. Paralysis of the bowel inhibits the two types of motion in the bowel, first the rhythmic peristaltic contraction wave which has to do with moving intestinal contents forward. The peristaltic wave is normal and should be aided in postoperative cases. Second there is the contraction that has to do with mixing of intestinal contents. It is not a wave as it occurs only in a localized segment of the intestine and should be combated since it is obstructive in nature.

Alvarez (7) has studied the peristaltic wave and believes it begins when swallowing movements are made. He starts peristaltic rushes in experimental animals by injecting water into the pharynx and making the animal swallow. Studies show however, that rushes may begin anywhere in the bowel. The presence of material in the loops of the bowel causes their tone to increase and the amplitude of the contraction to increase. Material is thrown backwards and forwards by the two ends of the loop until the upper end seems to overcome the lower, then down goes the peristaltic rush.

Sollmann (60) states that the entire gastrointestinal tract is innervated from both antonomic systems. The sympathetic supply comes through the splanchnic and mesenteric ganglea. The parasympathetic supply from the esophagus to the ileum is furnished by the vagus. The eirgens and pelvis

innervate from the colon and anus. The functions of the two systems are reciprocally antagnositic. Parasympathetic stimulation generally augments the contractions or tone of both coots of the muscular tube. Sympathetic stimulation auguments the sphincter tone and inhibits the muscular tube. This reversed arrangement of the sympathetic naturally simplifies their functional cooperation. The interinsic functions of the intestinal musculature, especially its tone play a very important role in their behavior and may profoundly modify their reactions to nerve stimulation, even to drugs. There is no longer any good reason to assume that the ganglionic nerve plexuses of Averbach and Meissner differ in function from the analogous ganglionic plexuses in most aulonomic organs. They have been interpreted as penpheral nerve centers for local coordination of peristaltic reflexes. According to this view they might be excited and inhibited by afferent impulses directly from the intestinal mucous membrane and muscle, as well as by efferent impulses from the central nervous system.

The chief features of smooth muscle are sluggishness of contraction; greater extensibility the exhibition of sustained contraction or tonus, even when isolated from the nervous system, the power of rhythmical contraction, double inervation, greater sensitivity to thermal and chemical influence and to certain types of mechanical stimulation as stretching, but a lower excitability to electrical stimulation and longer chronaxie.

The treatment of postoperative distention and gas pains then is such so as to restore or stimulate the normal bowel activity. The first treatment and possible the most popular is the use of enemas. They produce their characteristic action by irritating the mucosa of the rectum, sigmoid, and colon, thereby producing contractions of those structures (17). Also to a certain degree they cause sympathetic reflex contractions of the small intestine. When an enema is given an amount of gas is expelled similar to that recoverable by use of

the retal tube alone, and not unfrequently a period of symptomatic relief follows. If the abdomen be carefully examined wubsequently little actual decrease in the girth would be noticed, and within a few hours distention would be found to be increased in a few hours. The explanation is apparent. The initial reflex results from expulsion of colonic gas due, not to stimulation of peristalsis, but rather to simple relief of pressure incident to the mechanical opening of the rectal sphinters. The exacerbation represents a reactionary goading of peristalic action in the small intestine which is purposeless and valuless partly because the movements are not properly coordinated and partly because of the inherent difficulty of expelling gas by the mechanism of peristalsis, even in the presence of orderly movements. If now another enema be given the patient, the cycle of events is repeated. The latter condition of the patient becomes progressively worse than the first, because frequent peristalsis easily leads to motor exhaustion (17)

McIver and associates (41) believe that enemas might do some good in the presence of distention of the colon and if it is questionable whether their use should be pushed if they do not seem to produce this result.

Graham (25) definitely states that enemas flush only the lower bowel and do not stimulate peristalsis in the small intestine.

Walters (64) uses enemas in cases where there is persislent accumulation of gas in the large bowel. The patient assumes the knee chest position after the enema which he believes helps straighten the kinks in the bowel and materially promotes explusion of gas.

Dixon (19) states -, "The practice of prescribing enemas within a week following abdominal operations shouldnot only be discourage, but should be abandoned."

Cuthing (17) believes a rectal tribe is capable of giving much relief without causing any other side effects. A rectal tube passed well into the

lower bowel will in a short time evacuate gas from at least a considerable part of the colon.

Cunningham (16) believes he has satisfactory results with use of rectal tubes.

Postoperative Purging

In 1918, Alvarez (61) suggested that it would be wise to abolish the routine purge usually given on the second or third postoperative day. Some of the nurses had remarked upon the fact that not infrequently every thing went well until the purge was given, and then everything went wrong. It seemed often to give rise to vomiting, gas pains and distention, or if they had been present before it seemed to bring them back. It doesn't seem sensible to give patients a purge so soon postoperatively because one cannot expect them to produce fecal material when, for several days they have had little or no solid food. The main reason for giving this purge is that ordinarily, the surgeon feels uneasy about his patient until the bowels begin to move. After that he feels that the worst dangers are over, but as the purge can do harm and cause much discomfort, it would undoubtedly be better sometimes if the surgeon would restrain himself a bit and wait patiently for nature. As some of the surgeons felt a certain amount of uneasiness about giving up such a long established custom, it was thought wise to observe the results of a non-postoperative purging and compare results.

Alvarez (61) watched 62 patients without postoperative purging and questioned them day by day. The condition of the previously purged patients was obtained from their histories an notes made by nurses. In analyzing these two groups of patients, no mention was made of the patient's condition on the day of operation because we must expect some pain and suffering at this time from anesthesia and the incision. Conclusions were based on records of 211 patients, of these - 146 had abdominal and 65 extra

abdominal operations. In this analysis the cases were divided into abdominal and extra abdominal groups because there is naturally more pain and vomiting in abdominal operations. Further, the cases were divided into three groups. Group one, those operated who had been purged before and after operation, Group two, those who had not been purged before the operation, but soon afterwards. Group three, those who had not been purged before the operation and who were given no enema or cathartic for at least 4 days after operation. The incidence of pain and vomiting in these cases is shown graphically on the chart. (See chart attached)

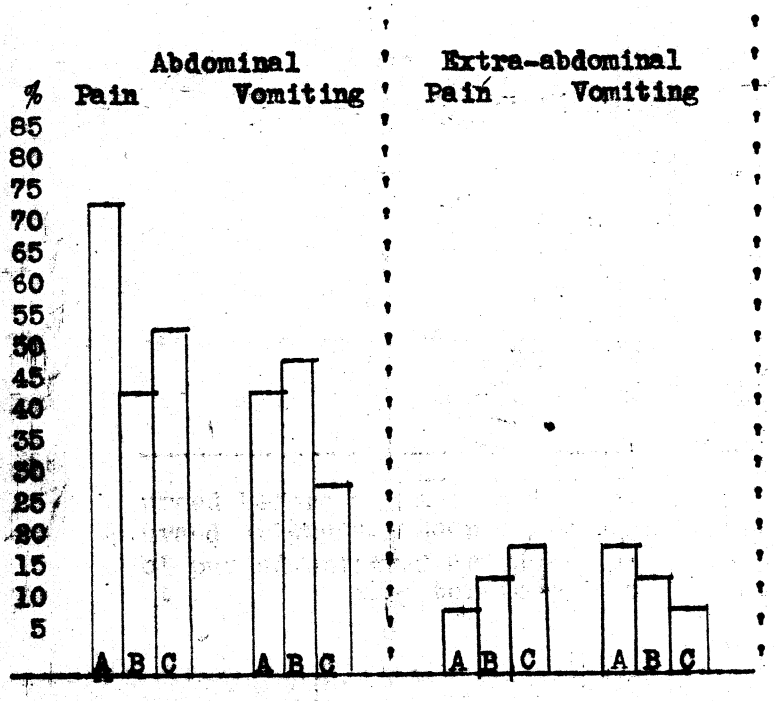
The first thing to note is that patients who did not have their abdomens opened sometimes had considerable pain and vomiting. Omission of the preoperative purge had no definite influence on the amount of vomiting, but it had a decided effect on the amount of pain in the abdominal cases reducing its incidence from 75 to 42%.

The delay in giving postoperative purge had a decided effect on the amount of vomiting, reducing its incidence from 45 to 30% in the abdominal group, and from 20 to 4 percent in the extra abdominal group.

In both groups, there was more complaintof pain when the postoperative purges were withheld. It means that a number of persons will be more comfortable if enemas are given. The idea is to make the treatment individual and not routine, because it is felt that cathartics and enemas should be withheld as long as possible after operation.

As some surgeons have worried about the danger of fecal impaction or auto intoxication, twenty patients were allowed to 6 days after operation without purging or enemas. None of these patients showed any ill effects, and several of them had spontaneous bowel movement within the period of observation. In the others an enema on the 6th day gave good results.

The essential point is that in a large hospital with young and inexperienced



A. Purged before and soon after operation.
B. Purged only after operation.
C. Not purged until after four days after operation.

house officers the standing order shall call for as little meddlesome interference as possible. If any patient develops symptons which require the use of purges or enemas they can always be prescribed, but they should not be made compulsory for the patient who is convalesing smoothly and rapidly.

Postoperative Feeding

There still exists much controversy among authors whether or not it is best to feed the patient soon after abdominal surgery. Emge (21) believes that as soon as possible the trend should be such so as to restore normal peristolsis and that the best stimulus for this is food and the earlier it is given the better for the comfort of the patient. McIver and his associates (41) also believe that an ordinary diet should be resumed as soon as possible since the intestine functions best under that condition.

Mahoney believes that a liquid starvation diet causes proliferation of putrefactive and gas forming bacilli. His efforts to restore the normal activities of the gastro-intestinal tract immediately following operations have been so successful in more than 300 loporatomies that his method of treatment shall be given. Briefly his method is about as follows with such modifications as may be made necessary by different conditions and varying temperaments. Patients are urged to eat solid food very soon after operation, usually the next morning. If not nauseated, they are served a tray the evening of the operation and encouraged to partake of dry toast, jello, cream of wheat, and similar foods. Water is permitted by mouth in such amounts as the patient may desire as soon as nausea has disappeared. Fruit juices of all varieties are strictly interdicted as it is felt that they have little or no caloric value and produce intestinal fermentation and result in gas formation. Besides the early feeding of water and solid food by mouth, it is also extremely helpful to supply some adjuvant which will furnish bulk retard bacterial growth

and thus help to combat intestinal stasis. Another interesting side effect of the treatment outlined is the fact that not as much weight is lost as when starvation methods are employed.

Intravenous Therapy

All authors agree that the body fluids should be restored as soon as possible postoperatively. They combat dehydration and restore the normal acid-alkali balance and the chloride in the blood, and help in preventing absorption of toxic substances.

Sar Louis (54) withhold fuilds and food by mouth for 48 hours postoperatively and supplies physcologic solution by rectal drip. He administers saline solution by hyodermoclysis in 2000 cc quanties the first 24 hours. If the patient is vomiting several times this quantity is given.

O Keefe (46) uses the Murphy drip method with 3% glucose and 2% sodium bicarbonate 200 cc of each are given every 4 hours during the first day and every 8 hours the second day. After nausea ceases the fluids are given by mouth.

Ottenheimer (49) allows his patients to take all fluids by mouth as soon as they are able. They first begin taking sips and later are allowed to drink top water at intervals of 4 hours for 48 hours.

Orr (48) makes use of sodium chloride solution as a definite treatment of postoperative cases. A high percentage of his patients having abdominal pain associated with moderate distention respond to intravenous injection of 20 cc of 10% sodium chloride with the passage of flatus and relief of pain. It is frequently necessary to repeat this dose from one to three times. In the more seriously ill patients 500 cc of 5% solution is usually used as an initial dose if the blood chlorides are much below normal. Experimental studies and clinical observations indicate that sodium chloride in

hypertonic solution increases the tone of the small intestine and stimulates peristalsis.

Suction

Cutting (17) makes uses of gastric suction along with the rectal tube. He passes a stomach tubes either through the mouth or nares. He finds that it empties the gas almost immediately from the stomach and duodenum. Though it is emphasized that the intestine is impotent to empty itself of gas for sometime postoperatively this is true only of portions somewhat removed from either end of the tract. There is some passage of gas into the stomach and is thus removed easily by the aid of the tube. Ochsner (45) makes use of the Wagenstien suction apparatus for over secretion of the stomach. He believes the over secretion causes stagnation and should be removed. He restores the fluids lost hereby intravenous saline solution. Sar Louis (54) also uses suction for removing all innocuous products and then uses the same tube for introducing sodium chloride solution.

Walters & Baush (64) and the great majority of authors use the duodeval tube for decompression and drainage of excess gastric secretion which occurs. They leave the tube for at least 2 days during which time enemas are not effective.

Heat

Heat tends to relax muscular spasm, and this principle may be used to good advange in cases which gas pains are persistent. The time honored turpentine stupes has relieved many a patient of distention and gas pains (McIver (41) Baker and Andrus (9) Cutting (17). Whether the turpentine used in the preparation of stupes has any particular value in itself is open to serious question. Turpentine is a local irritant and rubefacient and shares

the somewhat questionable advantages of other counterirritants. Undoubtedly the primary beneficient action of stupes is dependent upon there heat content. Probably in some cases particularly in very thin persons, direct transmission of heat is possible through the skin and subcutaneous tissue to the musculature of the interior abdominal wall. However, many patients present an intermediate pad of fat through which locally applied heat does not, in all probability penetrate for any considerable distance. For this reason, probably most of the effect of local application of heat is dependent upon reflex dilitation. Both the abdominal musculature and intestinal musculature respond clinically. Ochsner (45) believes there is dilitation of the somatic vessels and a concomitant contraction of the splanchnic vessels. Associated with the splanchnic vessels there is a decreased secretion into and increased absorption from the gut and on increase in the tone of the gut wall.

The hot stupe is not, however, really the most desirable form of heat application, provided that the theraputic action of turpentine be not considered of particular importance. Considerable portions of the abdomen are characteristically covered by dressings, and therefore the available surface to which stupes may be applied is ordinarily somewhat restricted. Furthermore, stupes not only impose an unwelcome burden of weight on the patients distended abdomen, but speedily lose heat and to be effective must therefore be frequently changed.

The electric tent or cradle is not subject to any of these disadvantages and presents certain additional desirable characteristics. It not only imposes no extra weight upon the patients abdomen, but it relieves the burden of the bed clothes as well. Heat is applied not only to the exposed portions of the abdomen but also to the part covered by dressings and flanks. The supply of heat is constant and can be regulated at will.

Infra-red irradiation, diathermy and possible other forms of physiothermy

may gain favor in the treatment of distention and gas pains as familiarity with these agenli and facilities for their application become more common.

Along with heat compresses Dixon (19) instills gently into the rectum 2-3 ounces of warm mineral oil or olive oil which the patient is asked to retain for 5 hours. The desired results are very frequently obtained with this treatment and it does not impose the dangers attending distention of bowel by the use of enemas.

Drugs

The fact that many methods are used to induce intestinal mobility for relief of postoperative intestinal distention and atonia and that several methods are likewise in use to suppress intestinal mobility in such conditions as cramps indicates that a lack of satisfactory exists in these respects. Literature is voluminous on the use and effect of these drugs which stimulate peristalsis by increasing the tone of smooth muscle.

Morphine

One of the earliest agents used in treating postoperative atony was morphine and strangely enough, continues to be used today. Such therapy amounts to ostrich like behavior for we flatter ourselves that by abolishing pain through overwhelming the higher centers with opiates we have corrected the condition even though the physical status of the patient remained unchanged, as evidenced by objective signs of distention. It cannot be argued that this early therapy utilized the stinulating influence of morphine upon the muscular tunic of the intestinal wall. Moreover, analgesic doses of morphine sufficient to control the pain of postoperative distention may and usually do,

result in conversion of generalized atony into spastic contractures alternating with areas of distention forced by blocked pockets of imprisioned gas, an unpleasant picture and one completely masked by analgesic effect of opiate used.

OKeefe (46) in his work on postoperative treatment states that morphine undoubtedly retards peristalsis. Mayo (40) also states that the one objection to the use of morphine is that is slows peristalsis and produces bloating and gas pains. He believes however, that if larger quantities of morphine are needed for the adequate relief of pain, these secondary objections to its use can be counter balanced by proper amounts of stimulants to peristalsis such as pituitrin and pitressin. Bargen and Jackman (33) found morphine very good in the relief of discomfort and pain, but that it had the unfortunate side effect of causing regions of the bowel to contract thus forming pockets filled with air.

Many writers on the subject believe in the efficacy of morphine in preventing postoperative distention. Ochsner and Gage (44) have found that the subcutaneous administration of morphine increases activity in patients and that it is therefore a valuable drug in the treatment of postoperative distention. Walton, on the other hand says that rest is best obtained by the use of morphine which has a tendency of restoring normal tonus to the intestinal musculature. The opinion that morphine sulfate restores normal tone to the intestinal tract rather than that it increases intestinal activity is held by most observers. Walters (64) disagrees with the conclusion brought out by other authors and believes that morphine administered in small doses not stop intestinal peristalsis but on the contrary stimulates it. Ochsner (45) uses morphine very much in his postoperative cases. He gives $\frac{1}{4}$ grain morphine sulphate every 4 hours whether the patient complains or not.

His results are good and has few patients complain of pain.

King and Church (34) did extensive experimental work on the action of morphine on the intestine. They concluded that there is little reason for apprehension with respect to the development of either distention or post-operative ileus as the result of administration of morphine in postoperative cases. Mastin (39) finds that the combination of morphine with one of the postoperative complications Cunningham states that morphine has a tendency to retard it to the extent that pain, fear and worry would. There still remain two schools of thought on the use of morphine. Some authors find it very good treatment while others believe it causes postoperative distention and gas pains.

Piturtary Extracts

The employment of extracts of the piturtary gland was a more rational therapy and a step forward in that the cause was being treated and not the effect. One objection to the use of the piturtary gland products is that the action is not constant. Some maintain that the primary action of the glandular produces is depression succeded by undesirable hypermotility and regardless of the dosage used a constant uniform action cannot be secured. Another objection to piturtary medication is the frequent occurrence of blanching reactions which have a terrifying effect on the patient and are not without actual danger.

Potter and Mueller (50) under tood a study to determine a method for prevention of postoperative distention using piturtrin. The s tudy was done at the Bellevue Hospital. They felt that if the tone of the intestine could be maintained during the first few postoperative days (through the atonic period) the smooth muscle could then resume its normal function. A hundred cases of acute appendicitis were studied. In 40 percent of the

cases, there was sufficient distention during the first 3 postoperative days to require the use of enemata and rectal tube. They found the action of pituitary extract to be violent and short in duration. From this study they advise against its use.

Blake (13) tried a similar experiment with higher dosages, giving postoperatively 1 dose at four hour intervals for 6 doses. In 100 abdominal cases of various types this routine was followed. It was found that the incidence of postoperative distention was lessened but there were numerous cases which continued to be a problem. These problem cases were those with distention before the first dose was given and those that became distended after the final dose of pituitrin. It was evident that the doses were not given early enough and long enough. Pituitary extract given to patients with no distention clinically had no indications of increased peristalsis. The effect of the drug is to maintain normal tone. He believes that posterior pituitary extract proves to an effective means of minimizing postoperative distention. When administrated before the onset of relaxation of the intestinal smooth muscle the result was a quiet abdomen. Cutting (17) further finds that pituitrin administration is not only followed by a flat, quiet abdomen but that normal defecation occurs.

Pitressin

Pitressin is similar to pituitrin but lacks the oxytoxic substance. Blake (13) substituted it in his experimental study of preventing postoperative gas pains for pituitrin the first dose was given before the operation if the patient had general anesthesia and directly after the operation if they had spinal anesthesia. In 90 out of a 100 cases there was no evident distention. Of the remaining 10 cases, eight became

moderately distended following the final dose of pitressin. In one biliary case there was much distention. This patient was extremely stout and there appeared to be no effect from administration of the drug. In the remaining cases, one of acute appendicitis with peritoneal abscess, the distention was the result of a mechanical obstruction and an eleastomy was necessary. There was no outward evidence of increased peristalsis in any case. The action of the drug appeared to be that of merely maintaining tone as with the use of pituitrin.

On the basis of his results in 94 consecutive cases treated with pitressin, Frazier (24) recommended its use in combating the distressing postoperative symptoms. It proved to prevent postoperative distention or if already present it gave immediate relief. Reactions were few, mild and transient and associated with no danger to the patient. The blood pressure apparently was not affected. The amount given subcutaneously varied from .5 to 1 cc every 4 hours given for as long as 96 hours. Seed & associates (57) found that pitressin administered in 10 and 20 unit doses before and after laporatomies was not notably beneficial.

Acetylcholine

Acetylcholine stimulates gastric and intestinal peristalsis like the other parasympathetic stimulants, but is milder and less toxic. It causes increased peristolsis of the normal type and not spasmodic. Injections also remove the gastrointestinal paries produced by operative troxima and peritonitis. Ochsner, Gage & Cutting (45) have produced experimental evidence that its action is neither constant nor conspicuous.

Peristaltin

Baker & Andrus (9) use a water soluable glucoside of cascara sagrada hypodermically to combat distention. This preparation is marketed as

peristaltin. It was given to a large group of patients, the initial dose being given at 7 P. M. the day of operation. The dose was varied according to the weight of the patient, one ampule being given every 3 hours until a total of 4 to 7 ampules had been given. Under this regime very little serious distention was encountered. However, some cases were met within which the use of enemas was necessary. They believe it is beneficial but not superior to other drugs used.

Tansy Oil

Sar Louis (54) described the effects of tansy oil on the intestines of rabbits and then has reported its use in a series of cases. He states that the effects are a stimulation of peristalsis and a paralysis of the sphinter. It causes expulsion of gas through the rectum, often eructation of gas without colic or pain. He further states that it was frequently administered after other remedies had failed and that it always improved the condition of the patient.

Novocaine - Spinal Anesthesia

Just how novocaine administered intra-spinally acts in curing ileus is difficult to explain with certainty. It induces surgical anesthesia of the lower half of the body, thus stopping afferent stimuli, and as judged by its action on blood pressure it blocks the splanchnics. The temporary paraplegia observed in animals testifies also its paralyzing action on voluntary motor nerves. It appears, therefore, that in intraspinal administration of novocaine we possess a method of temporarily blocking transmission through the spinal cord. The reflex paralysis of bowel movements

in dogs by laporotomy or by intraperitioneal injection of iodine, or by severe intraabdominal traumatism, is promptly abolished by spinal anesthesia with novocaine.

Asteriades (8) uses spinal anesthesia systematically in the treatment of postoperative distention and gas pains.

A detailed study of 900 cases by Lehman, Risher and Beppers (35) demonstrates that the postoperative course following spinal anesthesia is less disturbed than that following general anesthesia

Physostigmine

Physostigmine or eserine increases the tone of the musculature and produces increased amplitude of contraction of the intestine. The action of the drug seems to depend upon either a direct stimulation of the motor end plates of smooth muscle or the plexuses contained within the intestinal wall, or possibly the drug increases the irritability of these structures to motor stimuli. Both experimental and clinical reports onthe use of physostigmine in the stimulation of mobility is indicated (17). Unfortunately, however, the stimulation of the entire parasympathetic system elicits a variety of effects in addition to that upon the intestinal musculature particularly an effect upon the cardio-vascular system. Physostigmine is definitely toxic to the central nervous system, particularly the spinal portion. Due to its high toxicity and variety of side effects elicited through its use, physostigmine has not been widely used (36).

Cunningham (16) is very doubtful about any benefit derived from the use of physostigmine. In a total of 162 cases studied over a period of 11 months in the Johns Hopkins Hospital during 1921 and 1922, the conclusion was reached that no benefits were seen from the postoperative use of physostigmine following abdominal operations on pelvic visera.

Prostigmine

Stednab (59) and his co-workers, in their work on substances capable of inducing responses similar to those induced by physostigmine, investigated the monoalkylcarbamic acids. Their investigations cumulated in the synthesis of dimethylcarbamic esler of 3 hydroryphenyl-trimethyl-amonium methylsulphate known as prostigmine. It is a synthetic compound resembling physostigmine, but differing chemically from this alkaloid by its less complicated structure and greater stability. It is marked by a pronounced action on peristalsis, a less pronounced miotic effect and almost complete absence of cardiac by effects.

Oeshliman and Reinert (1) found in the frog, that physostigmine in a concentration of 1: 1000 often stopped the isolated heart in diastole, whereas in identical concentration prostigmine at most cause a slight degree in amplitude. In 1:100 concentration of physostigmine almost invaribly stopped the heart in diastole but in corresponding concentration of Prostigmine usually caused only a decrease in amplitude. With isolated rabbit intestines prostigmine is still active in dilutions of 1:5,000,000, in some cases a definite increase in toxicity was found in dilutions of 1: 7,500,000.

Berk (22) observed that the isolated frog heart subjected to the action of strophanthin was stopped in diastole following treatment for from 5-7 minutes with a 1:2000 solution of physostigmine. Under similar conditions, prostigmine solutions of varying concentrations (1:5000 - 1:8000) were without influence and stopped the heart in systole.

Rothschild (22) compared the peristaltis action of prostigmine with that of other parasympatheticomimetic substances on the normal isolated small intestine of the guinea pig. He found that prostigmine had a decidedly stronger peristaltic action than had physostigmine on the intestine rendered atonic by atropine or adrenaline. It restored toxicity to a greater than normal degree. Under

the influence of papaverine the tonus of the intestine slowly decreased. Treatment with protigmine checked this decrease and gradually stimulated the intestine almost to normal. Under similar conditions, physostigmine caused greater variations of tonus but did not restore normal peristaltic conditions the tonicity remaining below its initial level.

Until recently protigmine in the field of surgery has been restricted almost solely to postoperative application as a treatment for distention and atony of the urinary bladder. For this purpose 1 cc ampule of a 1:2000 solution is employed. A solution, having a concentration of 1:4000 is now available (prostigmine prophylactic) for use as a prophylactic against distention and bladder atony. Lewis and Axelman (36) have developed a technique of administration and it is recommended that the contents of a 1 cc ampule be administered every 6 hours starting a day before operation and continuing until the second or third postoperative day.

Schlaepfer (55) uses prostigmine (1:2000) in 1 cc doses every 8 hours and has very satisfactory results. He found that gas pains were markedly reduced if not completely avoided, and nausea if present, was reduced in duration.

Saegesser (53) using prostigmine found that in 88% of his cases flatus was expelled after 20 to 90 minutes after the first postoperative injection. In 56%, a bowel movement occurred after 35 minues to two hours after injection. There were no marked changes in the blood pressure and the pulse, even in old individuals did not fluctuate markedly. Miosis was seldom present and if present lasted only two to three hours.

Harger and Wilkey (28) find that prior to the use of prostigmine, from 60 to 75% of their patients complained of subjective symptoms or exhibited objective symptoms of intestinal atony. Administration of protigmine reduced the percentage to a negligible minimum. They find that prostigmine has a wide

margin of safety. It may be given in more frequent intervals or in longer or less frequent intervals and they find that the results are all satisfactory. Doses of 1 cc - 1:2000 solution given at 2 hour intervals to patients ranging from 14 to 68 years with no demonstrable ill effects.

Hendler (31) employed prostigmine prophylactically in some 180 cases, whereas in 77 additional cases this drug was used only when distention became manifest. His technique is to administer a 1 cc ampule of prostigmine (1:4000) 24 hours before the operation is scheduled, and to continue medication at intervals of 6 hours until 12 doses have been given, the last dose being followed by a soap suds enema. In only a few cases he had to give more than 12 doses. In emergency cases where there is no opportunity for premedication, prostigmine was started immediately postoperatively or when early distention was noted. In these cases which numbered 69, as a supplement, rectal tube installation and irrigation with warm saline was carried out with injections of prostigmine. The results were excellent.

In a second review, Hendler (31) had 249 cases in which prostigmine was used with special reference to 179 cases in which prophylactic treatment was carried out. Comparing these cases he has found that with a similar number of cases in which various other prophylactic agents were used, the instillation of routine use of this medication, both patient and nurse were disturbed by the necessity of repeated enemas, rectal tubes and whatnot for the relief of the patient's distress. Former records covering a similar period and group of cases indicate that where prophylactic treatment is not instituted at least 50% of cases will show subjective symptoms of distention or gas pains or both. The feeling of security which prostigmine prophylactic gives to both the patient and surgeon, and the fact that it has been found to be an effective prophylactic agent against distention

and "gas pains" has been made a routine procedure on the surgical division of the Metropolitan Hospital. More and more hospitals are making the use of prostigmine prophylactic a routine procedure as the popularity of this new effective drug is spread.

Four cases shall be reviewed from the work of Harger & Wilkey (28) to illustrate the specific and gratifying effect of prostigmine prophylactic (1:4000) solution.

Case 1

A.S. a white youth, aged 18, admitted to the Hospital October 28, 1936, with acute appendicitis of 53 hours duration, was found at operation to have ruptured appendix, with diffuse peritonitis. Appendix was removed and abdomen closed without drainage.

On the first postoperative day there was moderate distention, no peristalic sounds were heard, and no gas or feces passed. On the second postoperative day, there was moderate distention, no gas or feces having been passed since operation. Patient was given 1 ampule of prostigmine at 10 A.M., the dose repeated at 12 noon and at 2 P.M. At 3:30 great quantities of gas were passed and peristalic sounds were heard at the rate of 22 per minute.

On the third postoperative day, prostigmine was given every 2 hours for 4 doses. The peristalic sounds were 25 per minute. The feces and gas were passed twice in 6 hours. The blood pressure on admission was 110/80 and at no time above 114/85 or below 108/90. The pupils appeared normal throughout the prostigmine medication. The patient did not complain of abdominal pain at any time during the course of prostigmine. An uneventful recovery ensued.

Case 2

J.V. a negro, aged 36, admitted to the Hospital October 29, 1936, with a history of a scrotal hernia of 4 years duration. He had blood pressure of 128 syslotic; 90 diaslolic on admission. He was given 2 ampules of prostigmine 2 hours before operation and one additional ampule one hour before being taken to the operating room. Eight feet of intestine were found in the hernial sac at operation. The intestine, however, was entirely collapsed and easily replaced into the abdominal cavity. On the first postoperative day, peristalic sounds were 14 per minute. No gas or feces were passed, but the patient was free from distention. No prostigmine was given.

On the second postoperative day, there was moderate distention. The peristalic sounds were reduced to 6 per minute, and the abdomen was definitely tympanitic on percussion. Four ampules of prostigmine were given at 2 hour intervals. During the evening, 4 hours after the last dose, the patient passed considerable quantities of gas but no hyperperistalsus occurred. The peristalic sounds increased to 17 per minute. A slight increase in blood pressure was noted at that time 132/94.

On the third postoperative day both gas and fecal material were passed twice within 7 hours. Prostigmine was continued, three ampules being administered, at the rate of one ($\bar{q}$) every 2 hours. The blood pressure was 130 syslotic, 90 diastolic and a slight noise was evident. The pupils, however, reacted normally to light and in accommodation. The patient was given 2 oz. of liquid petrolatum. He voluntered the information that he felt "five" and except for a superficial wound infection which promptly responded to hot moist dressings, made an uneventful recovery.

Case 3

Mr. V. W. a white man, aged 47, admitted to the Hospital November 18, 1936, in severe shock showed evidence of peritonitis and pneumoperitoneum. No preoperative medication was administered. At operation a ruptured gastric ulcer was found and fluid and gastric contents were found in the abdominal cavity. The ulcer was sutured and the abdomen closed without drainage.

On the first postoperative day, marked distention and tympanitis occurred; peristalic sounds were on four per minute. Wangensteen decompression was begun and parenteral fluids were given. No feces or gas were passed.

On the second postoperative day, distention was still marked; no gas was passed nor were any peristalic sounds heard. Solution of posterior pituitary was given, one ampule every two hours for five doses. No gas had been passed by midnight, and enemas were entirely without results.

On the third postoperative day, at 8 A.M., two ampules of prostigmine were administered, followed by a similar dose at 10 o'clock. Doses of three ampules were then given at intervals of two hours. At 2 P.M. a low saline enema resulted in expulsion of much gas and fecal material.

On the fourth postoperative day, distention was much diminished and patient was passing gas very freely. Prostigmine was continued in one ampule doses every three hours for four injections, and a normal bowel movement occurred at 7 P.M.

On the fifth postoperative day peristalic sounds were eighteen per minute and distention had vanished. The patient went on to recovery with no complications. The blood pressure and the eyes were normal throughout.

Case 4

M. D. a negro, aged 39, admitted to the hospital November 7, 1936, with a diagnosis of chronic cholecystitis and cholelithiasis, in addition presented evidence of marked bowel spasticity and distention. Two ampules of prostigmine were given at 9 P.M. the night before operation, another ampule at 8 A.M. the following morning and one immediately preceding the operation. Both the large and small bowel were found to be totally collapsed. The gallbladder was easily found and removed without difficulty and the abdomen was closed with the liver bed drained.

On the first postoperative day there was no distention; the condition was good.

On the second postoperative day there was slight distention; no gas or feces were passed; there was some vomiting.

On the third postoperative day the abdomen was moderately distended. Solution of posterior pituitary, two ampules was given at 8 A.M. and one ampule every 2 hours for distention.

Gas was passed at 4 P.M., but the marked elevation of blood pressure, 20 points systolic, convinced us that further use of posterior pituitary extract be omitted.

On the 4th postoperative day prostigmine was administered for distention -- two ampules at once repeated in two hours and followed by one ampule every two hours for four doses. At 9:00 P.M. both gas and feces were passed. The blood pressure remained normal.

On the fifth postoperative day gas and feces were again passed with relief of distention. Prostigmine was given every two hours for four doses, with excellent objective and subjective results. After the 4th day, slight contraction of the pupil was noted, and from then on an uneventful recovery ensued.

Conclusions

Purgation preoperatively has been proved time and again as one of the etiological factors of postoperative distention and "gas pains." Even so tradition seems to prevail over new ideas and preoperative purgation goes on. In 1922 Taylor, Terry and Alvarez (61) showed that by omitting the preoperative purge the incidence could be lowered from 75% to 43%. Operations that open the peritoneal cavity, or without opening it, involve the tissue in juxtaposition to it and cause a derangement of the intestines. This surgical trauma due to handling and manipulation of the gut is characterized by general or regional cessation of intestinal movement, and a specific disturbance of the mesenteric circulation. As a result the gas balancing mechanism is upset and gaseous distention ensues. If motor and vaso-motor phenomena are marked and prolonged and the distention reaches a higher grade the venous return from the intestinal vessels suffers additional retardation owing to the stretching of the mesentery and the raised intro-peritoneal pressure. The wall of the distended intestine becomes paralyzed and hemorrhage occurs at multiple points producing a series of mechanical obstructions. The greatly impaired through the mesenteric veins is followed by exudation into the lumen of the intestine, most marked in that section where venous congestion is at a maximum, and the fluid exuded undergoes a corrupting change whereby it becomes toxic. These events are not specifically related to injury or exposure of the intestine, for they can occur after operations which do not open the peritoneal cavity, and this, together with the fact that the operative area is very commonly at a distance from the area in which the events take place, can only be explained by the hypothesis that the motor and vasomotor disturbances in the intestine, which are fundamental to the derangement

are caused by an agent generated somewhere in the tissue that the operation has traumatized.

The incidence of "gas pains" does not seem to be increased in septic surgical procedures. Just as many aseptic cases result in distention and "gas pains" as do septic cases. Many septic cases are not followed by distention and have a smooth recovery period.

The length of the operation has a distinct relation to the presence of distention and gas pains as does the length of preoperative hospitalization. Several workers report more severe gas pains after long operations, but they worn not to sacrifice skillfulness for a time record.

The part anesthesia plays in causing postoperative intestinal distention is unsettled. Most authors say it has its part in it but that it is very minor. Some workers find fewer cases of postoperative distention when using spinal anesthesia rather than general anesthesia.

Gas pains are just as common in men as in women and are most common between the ages of 20 and 50 years. The nervous type of people are more likely to have gas pains.

A report has been made of postoperative "gas pains" without gas. Patients suffering from "gas pains" were examined and found to have no abdominal distention. Roentgenogram examinations showed no gas in the stomach or bowel. This is a new study and so far little work has been done on it.

Treatment

Enemas and rectal tubes have been used for many years as treatment for postoperative "gas pains" and distention. We find many surgeons avoiding the use of enemas but whenever other treatment fails they come back with

the enema and rectal tube. The enema is able to do just so much, but is found to give some relief at least temporarily to the patient. Post operative purging for the relief of "gas pains" is an old custom and has now been nearly completely put out of use.

Authors are not in agreement as to postoperative feeding. Those advocating food as early as possible after operation state that the normal activities are best restored and there is less weight loss in the patient. Those administering a fluid starvation diet state that the gastro-intestinal tract is unable to handle the food and stagnation and fermentation results.

All authors agree that the patient is to be given introvenous saline and glucose solutions as soon as possible postoperatively. This combats dehydration and avoids absorption of toxins from the intestinal tract. Orr(48) uses hypertonic saline soloutions introvehously to initiate peristoltic activity.

Suction by Wagensteen method is in use in most hospitals for reducing distention. It also removes excessive gastric secretions and toxic products. Much relief is frequently obtained by suction, especially when the gas is accumulated high in the gastrointestinal tract.

Treating postoperative distention with heat is an old method of treatment. Turpentine stupes, hot water bottles, and electric bed cradles as well as deathermy are being used. There is a reflex stimulation of the splanchnic vessels and promotes better circulation of blood in the intestine. Many cases of striking results have been reported.

The treatment of postoperative distention and gas pains with drug is a later method. We find many drugs and synthetic compounds used daily in the hospitals today. Morphine is very popular among surgeons but it has a tendency to relieve the pain and not to treat the cause. To relieve the distention and gas pains one must promote activity of the gut, that is,

initiate peristaltic wave which removes the gas into the colon from where it is easily expelled.

Extracts of the pituitary gland have been used as treatment but the reactions have been violent and uncontrolled by dosage. Very few surgeons use pituitary extracts in combating postoperative distention.

Acetylchorine is a gastro intestinal stimulant but few reports of its usage appear in the literature. Its actions are neither constant nor conspicuous.

Reports of successful treatment with peristaltin appear but the treatment is not popular. It is used postoperatively in small doses given every 3 hours. Its use is justified but cheaper and more stable drugs replace it.

Several authors find that a novocaine spinal anesthesia is excellent treatment for severe cases of distention and gas pains. Very few surgeons make use of it at the present time. It has a more important role in the treatment of ileus.

A new era of treatment was begun when physostigmine was used for the treatment of postoperative "gas pains." This drug has excellent effect on the intestine giving rise to strong peristaltic waves. Besides this, physostigmine has a variety of side effects on the caido-vascular system and central nervous system. For this reason the use of physostigmine has been with held. A derivative of physostigmine has been synthesized and is called prostigmine. Prostigmine has definite action on the gut giving rise to controlled peristalcis and no side effects on the caidio vascular system or central nervous system.

Prostigmine is marketed in two coneentrations 1:2000, the theraputic, and 1:4000 the prophylactic solutions. Injections of 1cc (1:4000)

prostigmine solution at 6 hour intervals, 24 hours before operation control distention and gas pains completely. This drug is now being used routinely in many hospitals today. The 1:2000 solution is used in cases of postoperative distention with excellent results.

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