INTESTINAL INTUBATION*

T. GRIER MILLER, M.D.
Professor of Medicine, University of Pennsylvania

SINCE its development in 1934, intestinal intubation has been modified considerably and workers, both in our clinic and elsewhere, have accomplished by means of it many things not originally in mind.

Intestinal intubation did not originate with Dr. Abbott and me, although we made it a practical procedure by developing a double lumen tube and attaching to that an inflated balloon. The balloon made it possible for us to enter the small bowel quickly, instead of taking three or four days as had been necessary previously. It also served as a means of recording pressure changes in the tract, and at the same time the double lumen tube supplied an extra lumen through which we could make unrestricted extractions of the bowel contents.

The first person to do intestinal intubation, so far as I know, was a Netherlands physician by the name of Scheltema. In 1908 he realized the possibilities from his observation of a horse hair protruding from both ends of the alimentary tract of a chicken. He also had observed strings dangling from the anus of dogs and cats. These important observations led to the development of the technic of inserting a mercury-filled tube through the alimentary tract of the frog and taking x-ray films to show it. Dr. Scheltema then performed a like experiment in a child.

Within the following year or two Dr. Max Einhorn, of New York, developed what he called a "duodenal pump." His objective was to secure material from the duodenum for the study of the pancreatic secretions. Later, in 1919, Dr. Einhorn intubated the bowel beyond the duodenum, developing his jointed tube for that purpose. This tube was unnecessarily long because at the time he did not realize that a tube of 10 feet length was sufficient to intubate the entire digestive tract. He succeeded in reaching the cecal area.

In 1920 when Dr. Einhorn's jointed tube became available, I was able to intubate the small intestine in the same manner he had. The first difficulty encountered was that the tube had such a small lumen it was impossible to secure intestinal contents in such quantity as to make the procedure worthwhile. The second problem was that it took four to five days to accomplish the intubation and the patients by the end of that time were usually completely exhausted.

I did not resume the matter until 1930. At that time Dr. Abbott wished to study the effects of drugs on the duodenum. For this purpose he attached a rubber condom to the end of a tube, inserted it in the duodenum, distended the bag and made kymographic records as he gave the patients a variety of

**Lecture delivered October 9, 1948 at the Bunts course on Diseases of the Digestive Tract at the Cleveland Clinic (slightly abridged from wire recording).*

drugs. He finally became discouraged because the bag continued to slip from the duodenum down into the jejunum each time the apparatus was set up and things seemed to be progressing favorably.

Eventually I suggested that he allow the bag to slip and observe the result. By this method of simply releasing the bag a roentgenogram taken four or five hours later showed the balloon to be in the cecum.

Thus more or less accidentally we discovered how easy it is to intubate the small intestine. The next step was simply to tie another tube to the side of the first one, just behind the bag, and allow the patient to swallow it. This descended into the terminal ileum and completed the principle of a new technic.

To simplify the procedure we developed the double lumen tube although it took a year to obtain a satisfactory one. Up to that time the rubber manufacturers had never made a double lumen tube, except for the short one employed by urologists, and considered it an impossible thing to do. Finally, by an extrusion process (the shorter ones having been molded over glass rods), a manufacturer undertook the production of the double lumen tube now in routine use.

The procedure is as follows: one lumen is connected with the balloon, and through this lumen the balloon, once it has entered the duodenum, is inflated. The peristaltic waves of the duodenum then take charge and push the foreign body to its destined position. Once the tube is in the desired place, the other lumen, open at its distal end, is used for the extraction of material from the intestine or for the introduction of fluids. The bag and its attached portion of the tube may be used for recording peristaltic waves on a kymograph.

It is also possible, instead of using the second lumen for the extraction of material, to put another rubber bag around its terminal aperture and so secure kymographic tracings from two parts of the small bowel simultaneously.

In the study of the small intestine we found that at the duodenal level the contents had an average reaction of about pH 6, while, as lower levels were reached, it became neutral, always being practically neutral at the terminal ileum.

We also studied the osmotic pressure, taking samples from different places along the tract. As lower levels were reached the osmotic pressure became nearer and nearer to the normal osmotic pressure of tissue fluids, about 300 milliosmoles. The osmotic pressure of the bowel contents is largely due to its chloride and bicarbonate content.

Glucose entering the small intestine tends to push the osmotic pressure above the normal level. We found that, under such circumstances the chlorides drop although the bicarbonate does not change much. Thus the osmotic pressure in the intestinal contents is not radically altered. As soon as one electrolyte enters another is displaced, and so nature maintains a more or less fixed osmotic pressure.

Later Dr. Richard Warren, devised a technic for blocking the pylorus. However, experiments proved extremely difficult and he spent a year perfecting the technic. The stomach appeared to displace anything inserted from the pyloric end, either throwing it back into the body of that organ or shooting

it through into the duodenum. He finally succeeded only by putting down a tube with two bags attached, getting one bag just above the pylorus and the other bag just below, then blowing up both of them. An extra tube, running alongside and beyond the distal balloon enabled him to determine whether or not any fluid was getting past the pylorus. Even with this technic he failed often, but in some instances he was able to block the pylorus completely. Under such conditions he was able to introduce a glucose solution, determine how much of it was absorbed and how much fluid was poured out into the stomach to dilute it. Relatively little sugar was found to be absorbed in the stomach, and yet the concentration of the sugar in the stomach was reduced. This was due to a considerable increase in the volume of the fluid. When he put in only 200 cc. of a glucose solution he was soon able to extract 400 cc., the stomach obviously pouring out fluid to reduce the osmotic pressure of the solution.

An even more elaborate technic was finally worked out for isolating the duodenum. Trained people became expert in assisting and swallowed as many as three or four tubes at a time. This could hardly be accomplished with the ordinary patient. One tube was used to extract from the stomach any material that might get back to that organ. Another little tube was employed for the introduction of the glucose solution directly into the duodenum, and if any of that were regurgitated back into the stomach, it was picked up by the first tube. Still another tube was used to control a bag which blocked the jejunum just beyond the Treitz ligament area. A final larger tube permitted extraction of the duodenal material. By this technic we were in a position to introduce a glucose solution into the first portion of the duodenum and to collect from its distal portion such material as reached that level.

It became apparent that an enormous amount of sugar can be absorbed in the duodenum, and also that additional fluid is poured out from the wall of the duodenum further to dilute the sugar present. This obviously is a means that nature has developed to prevent a hypertonic solution from getting in the small bowel. Consequently, no matter how hypertonic a glucose solution may be on admission to the stomach, its tonicity is slightly reduced in that organ, further reduced in the duodenum, and by the time it gets to the jejunum it is isotonic with the tissue fluids.

By means of two tubes, one three-lumened and one two-lumened, we were able to collect material at the same time from different areas in the stomach, the duodenum and the upper jejunum and to determine the glucose content of each. The accumulated data on material from the stomach, duodenum and the upper jejunum indicate that no matter what the glucose concentration in the stomach (15 to 50 per cent) it is reduced to about 6 per cent as it reaches the jejunum. That is not in excess of 300 milliosmoles, which represents the normal osmotic pressure for the small intestine. Meanwhile in the duodenum the concentration was in the neighborhood of 13 per cent, which has been shown by other workers to be optimal for absorption from that organ. These are not new observations except that they have been made on the human subject.

In a discussion of some clinical applications of the work let us consider the "dumping syndrome," which so frequently follows a gastric reaction. Dr. Machella has worked out the mechanism of this disturbance. Usually the symptoms develop as soon as the patient starts to take food. He becomes nauseated, has a sense of fullness or discomfort, and sometimes pain, in the epigastrium. He often has a generalized feeling of warmth, and yet his forehead is cold and clammy. Diarrhea frequently follows. Because in some cases hyperglycemia has been discovered and in others a late hypoglycemia, it has been considered that the syndrome might be due to a disturbance in the sugar metabolism. What actually occurs is that hypertonic material goes directly from the stomach into the jejunum, where under normal conditions it is isotonic with the blood plasma. The duodenum which ordinarily reduces the concentration to a level that is acceptable to the jejunum, is out of the picture after a gastrectomy, and so this hypertonic material without the usual change drops directly from the stomach into the jejunum. There it sets up certain abnormal reactions and an enormous outpouring of fluid into the jejunum occurs in an attempt to bring the concentration down to the proper level. This sudden increase in volume has been demonstrated by injections into an isolated jejunum loop. The excessive quantity of fluid overdistends the jejunum and so causes distress and nausea. Secondly, nature tries as quickly as possible to absorb the excess sugar that is present, in order to reduce the osmotic pressure to a normal level. This accounts for the hyperglycemia. Moreover, nature attempts to disperse the hypertonic material throughout the tract in order to bring it into contact with a larger intestinal surface so that the sugar can be more readily absorbed. This results in diarrhea.

The management of the "dumping syndrome," is simply the withholding of food from the patient in a hypertonic state or delaying its admission to the jejunum. For the latter purpose reoperation has been resorted to in some instances, narrowing the aperture between the two organs.

A brief discussion seems indicated about our experience with patients having intestinal obstruction. Dr. Abbott and Dr. Charles G. Johnston first suggested that intubation might be performed in such patients. The difficulty, however, lies in the passage of a tube and a balloon down the small bowel when that organ is enormously distended. It is true that the distended intestine loses its peristaltic activity, but it must be remembered that wherever the tube goes, the contents of the bowel are siphoned off. With a properly arranged apparatus this aspiration occurs just distal to the balloon. Thus the balloon itself, being proximal to the open lumen, is always in a deflated part to the intestine, and as the bowel is deflated its peristalsis returns. This explains the onward progress of the tube in obstruction. It occurs only as the distention is relieved. With an atonic condition of the bowel wall in what is known as adynamic obstruction, the wall really is not paralyzed. It is simply so distended that it cannot function, and as soon as the contained gas or fluid is removed the bowel functions again and the peristalsis is in normal direction. The idea that antiperistalsis develops when the bowel is obstructed is erroneous. No

one has observed antiperistalsis in the small intestine below the middle of the duodenum.

We do observe fecal vomiting, however, which indicates that in some way the feces get back from the lower part of the intestine into the stomach. An English physician, Dr. Brinton, explained this as far back as 1880, before we knew about intubation. He illustrated the mechanism by a perforated piston in a syringe, the piston pushing downward but allowing the liquid contents of the syringe to come upward through the perforation. In intestinal obstruction the waves come down from above, but push the bowel contents against the blocking lesion which causes the contents to go backward as a central stream. Dr. Brinton, in further support of his theory, gave animals with an obstruction castor oil orally, and by puncturing the bowel just above the obstruction observed that the castor oil had descended that far before coming up again. Thus he demonstrated that the vomitus in such cases actually did come from the area of the obstruction, and peristalsis obviously carried it to that level.

In regard to intubation studies on drug effects, there has been a controversy among pharmacologists as to the result of morphine on the digestive tract. Some believe it causes contraction, while others insist that it brings about relaxation. Dr. Abbott investigated by intubation its action on the duodenum. With the balloon inflated in the duodenum and connected with a kymograph, he gave the patient ¼ gr. of morphine. The duodenum contracted and remained so for about fifteen minutes, but then began to relax and soon was more relaxed than before the drug was administered. This condition persisted for an hour or more. The same reaction, occurred lower in the tract. Thus obviously the drug is capable of producing both effects. It causes contraction, but the contraction occurs for only about ten or fifteen minutes and is followed by a period of an hour or more when the wall is relaxed. This suggests that it is unwise to administer morphine to a patient who has a bleeding duodenal ulcer, the bleeding being more readily controlled when the wall, gastric or duodenal, is tonic.

Later Dr. Kendall Elsom made similar studies on the effects of atropine on the duodenum, small intestine and colon. He was able to confirm in man its relaxing effect, previously demonstrated conclusively in animals. The effects of pitressin on the small and large intestine also were investigated by Dr. Elsom. In one patient the balloon reached the splenic flexure of the colon, and it was possible to secure roentgenograms that showed the balloon distended and, after administration of the drug, definitely contracted. Simultaneous records from the terminal ileum and the colon seemed to indicate that the contractions in the two parts of the tract, due to the pitressin, occurred alternately. Pain sometimes accompanied the contractions of the colon.

Dr. Elsom also devised an ingenious metal bucket for studies of intestinal digestion. This could be opened or closed by pressure changes in the lumen of the tube to which it was attached and could be introduced into the bowel. To measure the extent of the digestion of protein he inserted a calculated quantity of meat into the bucket, closed it and then passed it to a designated

part of the intestine. There the perforations in the bucket were opened to allow the entrance of bowel contents. After a fixed time the bucket was again closed and removed. By such a means he seemed able to demonstrate, in ulcerative colitis patients, some impairment of protein digestion in the small intestine, an important observation if confirmed.

A procedure has been developed by Dr. Machella involving intestinal intubation for the management of stubborn cases of chronic idiopathic ulcerative colitis. It allows the administration of a highly nutritious liquid diet and the removal, by an in-lying tube, of such residue as reaches the terminal ileum. Thus it affords a means of supplying the needed fluids, calories and nitrogenous materials, and at the same time permits rest to the diseased colon. Recently Dr. Machella has been giving the patients an amigen-dextrimaltose mixture and in most instances has obtained gratifying results.