

cutting down on the hernial sac I found a small defect in the abdominal wall with a small portion of the omentum projecting through it. The omentum was readily returned and the opening easily obliterated with a few sutures.

Dr. Bloodgood tells me that he observed a case of hernia of the abdominal wall at the semilunar line, that was between the rectus muscle and those forming the lateral abdominal wall. The sac contained non-adherent loops of small bowel. The condition was readily cured. In our case the opening was also at, or near, the semilunar line, and instead of small bowel passing into it the ovary had for some reason occupied the space and later had gone on to tumor development. It is just possible that this weakness in the wall had become particularly accentuated during a pregnancy and that the ovary during its ascent with the pregnant uterus had dropped into the cavity.

In conclusion, I wish to thank Dr. Fred Ray for his kindness in ferreting out the references to the articles read by me in the preparation of this paper, and I am especially indebted to Mr. Max Brüdel and the Foundation of Art in Medicine of the Johns Hopkins Medical School for the excellent illustrations.

SOME APPARENTLY OBSCURE CONDITIONS OF THE GASTRO-INTESTINAL TRACT AND THE PRACTICAL APPLICATION OF THE RÖNTGEN RAY IN THEIR DIAG- NOSIS *

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We are not dealing with the obscure conditions of the gastro-intestinal tract as they arise, but mostly with the common pathologic states, often misinterpreted on account of the unsatisfactory methods of diagnosis at the present day. The subject is so broad that we have decided to restrict our paper to the size, position, and motility of the gastro-intestinal tract. Normal patients, or patients with splanchnoptosis with or without intestinal symptoms, constitute our particular theme. Cases of ulcer and malignancy have been omitted on account of limitations of space.

All the cases under consideration have been studied first with regard to the physical signs and the ordinary tests for gastro-intestinal secretions and contents. The Röntgen ray has been used as an aid and confirmatory agent in diagnosis. Whereas due consideration in every case has been given to the history, subjective and objective signs, and examination of secretions, we have found progressively downward and they become confirmed the previous diagnosis, it has also shown the error of the previous diagnosis in an astonishing number of cases. A great difficulty in gastro-enterologic work has been the lack of certainty in the results of clinical tests for size, position, and motility of the hollow viscera. The Röntgen ray solves this problem. Every day we

meet patients with moderate or severe grades of constipation, not due to obstructions from tumors. They have usually gone the rounds of numerous physicians or dispensaries, and are relieved only by the continuous use of laxatives or cathartics. Their course is nearly always progressively downward and they become confirmed neurasthenics or slaves to the drug habit. Occasionally, without any scientific accuracy on the physician's part, these patients, if they are fortunate, improve by treatment on general principles.

In previous examinations, chemical tests for motility of the stomach and intestine have been unreliable. Peristalsis of the stomach and intestine sometimes can be seen through an abdominal wall that has been thinned out, usually in advanced emaciation. The entire length of time that food takes to pass from the mouth to the anus can be determined by the ingestion of indigestible and non-absorbable foods or chemicals, such as bismuth salts, which can be recognized in the stools. This does not indicate, however, the length of time consumed in digestion by the different portions of the alimentary tract, and is often inaccurate in determining the time of digestion. Tests for determining residual food in the stomach are tedious and very annoying to the patient, and determine only approximately the final result. This, with our other important data, can be shown by the Röntgen ray, in a properly conducted series of plates.

Radiographs of the alimentary tract after the administration of some insoluble substance which obstructs the Röntgen ray, such as the bismuth salts, have been used in Europe since 1904, by Rieder,¹ Holzknecht,² C. Kaestle and J. Rosenthal,³ Franz M. Groedel,⁴ A. F. Hertz,⁵ and others; and in this country by G. E. Pfahler,⁶ Hulst,⁷ Pancoast,⁸ Cole,⁹ and others. The methods will soon be universally applied. Rieder was the first to give large amounts of bismuth salts. He gave from 40 to 50 gm. of bismuth subnitrate in a meal of boiled rice, barley broth, potato puree, spinach, or boiled meat. The bismuth can be administered by mouth or by rectum. Haenisch¹⁰ was the first to give the bismuth per rectum, in the following formula: bismuth subcarbonate 75 gm., bolus alba 300 gm., water 1,000 c.c. We use the bismuth rectal injection and find it a valuable adjuvant to the method by mouth. Kaestle used zirconium oxid instead of bismuth because it was more insoluble. Of the salts of bismuth, the subnitrate was at first extensively used, but it has caused toxic symptoms. Cases of poisoning due to the impurities in the preparation, or to the absorption of the nitrites formed in the intestine, have been reported by E. G. Beck,¹¹ W. Alexander,¹² L. Lewin,¹³ and many others. The subcarbonate of bismuth is apparently non-poisonous and acts in the same way as the subnitrate toward the Röntgen ray. We have had no toxic symptoms in over forty tests in which large quantities were given. Examination of the bismuth stool shows the bismuth passed through chemically unchanged.

1. Rieder, H.: München. med. Wchnschr., August, 1904.

2. Holzknecht: Berl. klin. Wchnschr., Jan. 29, 1906; also: Mitt. a. d. Lab. f. radiol. Diag. u. Therap., Vienna, No. 1, 1906.

3. Kaestle, Rieder and Rosenthal: Arch. Röntg. Ray, June, 1910.

4. Groedel, F. M.: Arch. Röntg. Ray, September, 1910, p. 156.

5. Hertz, A. F.: Discussion on Groedel's paper, Arch. Röntg. Ray, September, 1910.

6. Pfahler, G. E.: THE JOURNAL A. M. A., Dec. 21, 1907, p. 2069.

7. Hulst: Physician and Surg., Detroit, 1905, xxvii, 391.

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9. Cole, L. G. and Einhorn: Radiograms of the Digestive Tract, New York Med. Jour., Oct. 8, 1910.

10. Haenisch: Rep. Am. Röntg. Soc., Sept. 29 to Oct. 1, 1910.

11. Beck, E. G.: New York Med. Jour., Jan. 2, 1909, p. 16.

12. Alexander, W.: Deutsch. med. Wchnschr., 1909, xxxv, 877.

13. Lewin, L.: München. med. Wchnschr., 1909, lxi, 643.

* Read in the Section on Practice of Medicine of the American Medical Association, at the Sixty-Second Annual Session, held at Los Angeles, June, 1911.
* From the Edward N. Gibbs Memorial X-Ray Laboratory and the Marcellus Hartley Foundation in Medicine.

Milk, as representing a suitable form of food, is now being used as a menstruum for the bismuth. A serious objection to ordinary milk is the early precipitation of the bismuth, but this can be overcome by the use of the fermented milks which hold the salts in suspension for a much longer time. Our experiments with bismuth suspended in various media demonstrate that the salts mixed with the fermented milk remain in suspension longer than in other fluid foods, as malted milk, sweet milk, buttermilk, and chicken soup. The next best substance is a thick chicken soup. (Fig. 1.)

For the average adult, 75 gm. of bismuth subcarbonate suspended in 500 c.c. of fermented milk is given with the stomach empty. Previous catharsis is unnecessary and inadvisable. The diet for the previous twelve hours must be light and exclusive of meat, fruits, and vegetables. All medication is omitted.

The radiographs have all been taken with the patient in the standing position. The distance from the anode to the plate is 24 inches, with the plate anteriorly and the anode on a level with the umbilicus. The illumination is dorsoventral, with one or two lateral views, as the

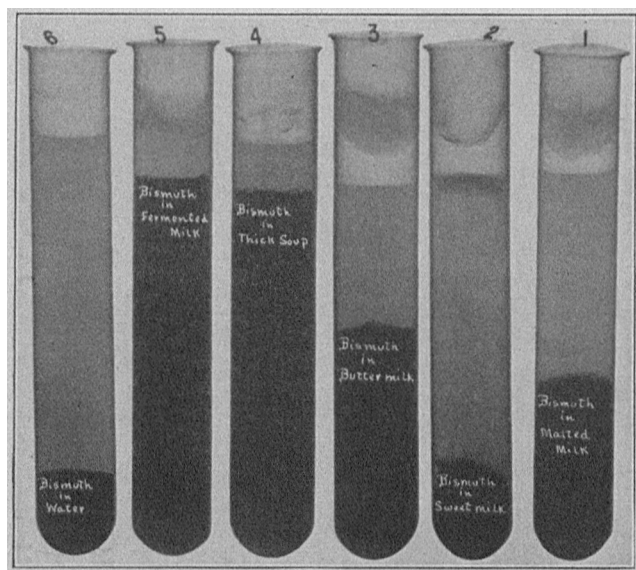


Fig. 1.—Radiograph of substances used for Röntgen-ray tests. Each test-tube contains an equal amount of bismuth subcarbonate. It shows the amount of settling fifty hours after suspension. 1. Malted milk and acacia. 2. Sweet milk. 3. Buttermilk. 4. Chicken soup. 5. Fermented milk. 6. Water and acacia. Note the remarkable stability of the suspension of the bismuth in the fermented milk.

occasion demands. The duration of the exposure is from one-sixth to four seconds, mostly under one second. It requires an average of from eight to twelve radiographs to examine a patient. Occasionally, a second series is necessary for a control, or a rectal injection to corroborate the colon findings. For experimental purposes, more plates have been taken than are ordinarily necessary for a routine examination. We find that the radiographs after the rectal injection do not give as natural an appearance to the colon as those taken after the administration of the bismuth by mouth. The plates can be taken much sooner, however, as the bismuth mass reaches the cecum within fifteen minutes and is then rapidly expelled per rectum.

We always try to make a primary, a secondary, and a final diagnosis. The primary diagnosis is made from the history, the physical examination, the examination of the gastric contents after a test-meal, and the exami-

ination of the feces and the urine. Other examinations are made as the occasion arises. The primary diagnosis is made previous to any consideration of the Röntgen ray.

The secondary diagnosis is made wholly from thorough consideration of multiple Röntgenograms, taken seriatim after the bismuth meal. In every case, the exposures are continued until the last trace of bismuth has left the alimentary tract.

The final diagnosis is made by carefully comparing the primary and secondary diagnoses and weighing the preponderance of evidence offered by the symptomatology.

In estimating the position of the viscera, our technic is to place markers on (1) the tip of the ensiform, on (2) the umbilicus, over (3) the tip of the ninth right costal cartilage, and on (4) the anterior superior spine of the right ilium. The umbilicus, contrary to what we expected, appears to be a fairly well-fixed point, except in very pendulous abdominal walls. It must be remembered, however, though these landmarks are sometimes uncertain, yet if their location is abnormal it is evident on physical examination, and hence allowance can be made.

We shall first mention some of the results, quite constant in nearly all our cases. Our studies on the esophagus have been entirely too superficial as yet to warrant the findings being chronicled. The points in fixation of the stomach agree with those described by anatomists. They are the esophagus and distal end of the first portion of the duodenum, which latter point anatomists say is firmly attached by the duodeno-hepatic ligament (Piersol¹⁴). In a normal, or at least a non-ptosed well-filled stomach, the shadow of the distal end of the first portion of the duodenum reaches the level of the upper border of the second lumbar vertebrae. The outline of the pylorus is situated opposite the junction of the second and third lumbar vertebrae. For the purpose of classification, we consider that if the lesser curvature is well up above the upper margin of the umbilicus, the stomach is not ptosed. The shape of the stomach varies according to the position of the subject. When the patient is in the standing position, in the greatest number of cases, the shape of the stomach resembles that of a fish-hook, and when in the recumbent ventral position, it simulates a steer's horn. This modifies former anatomic views based on dissections in the dorsal decubitus. When the patient is in the standing position, the long axis is vertical; when he is in the prone position, the long axis in the same subject may be oblique or almost transverse.

In order to determine accurately the size, shape, and position of the stomach, studies of plates made within a few minutes after ingestion of the bismuth meal should be made. During activity of the stomach, peristaltic waves can be seen distinctly as constrictions on the greater and lesser curvatures. These are differentiated from permanent constrictions by the changes in form of the organ in the succeeding plates or by the fluoroscope. The former is, in our estimation, more accurate and practical than the latter. The cardiac end of the stomach empties very quickly and shows the rugae often plainly marked out by the bismuth. In cases of gastric fermentation, the gas rises in the cardiac end and pushes up the diaphragm, as can be well demonstrated in the radiograph.

The average time required for the normal stomach to empty itself completely of a full bismuth meal is, in our

14. Piersol, George A.: Human Anatomy, 1909 ed.

experience, from two and one-half to four hours. It is difficult to prove atony of the gastric musculature, but stasis and permanent pouches can be demonstrated, some of the bismuth remaining in the lower pole as long as ten hours after ingestion.

The motility of the stomach in nearly all cases appears to be most rapid during the early part of digestion. Some stomachs seem to rest after the first thirty minutes to an hour. After that, they still contain about one-quarter of the amount of the original contents, which is discharged in a variable time. The end motility of the stomach is apparently not influenced by the amount of free hydrochloric acid in the gastric contents. The early activity in certain cases of hyperchlorhydria is increased, however. This is demonstrated by the serial radiographs taken up to the final emptying of the organ. The dilated stomachs almost invariably show a slow motility, especially in completion of the act.

The study of the small intestine has so far been unsatisfactory, especially so of the duodenum, on account of the rapidity with which the bismuth meal passes through this part. The first portion of the duodenum can usually be identified by a small mass of bismuth, the so-called "bishop's cap," separated from the pyloric antrum by the outline of the pyloric muscle. The pyloric ring, as thus seen, averages $3/16$ of an inch in width. In most of our cases, splashes of bismuth appeared in the jejunum within a few minutes after the entrance of the meal into the stomach, and it is the exception to find the small intestine free from bismuth within ten minutes after taking the food.

The course of the bismuth in the jejunum is first to the left iliac region, but it quickly settles in the median line. It appears between the umbilicus and the brim of the true pelvis in non-ptosed conditions and enters quickly the true pelvis in ptosed states.

We find the progress of the bismuth in the small intestine to be comparatively rapid. In the twenty-seven cases studied for this paper, the earliest time within which the bismuth has reached the cecum was one hour. This occurred in two adults, and in three children about twelve years of age, one of whom had a pan-visceroptosis. Rieder¹ and Goldthwaite¹⁶ consider two hours to be the most rapid time in which the bismuth can reach the cecum, while Groedel and Hertz say that they have not seen the bismuth reach the cecum in two hours, and that four hours is the shortest time it takes. In our slowest cases, so far, the bismuth has taken five hours to reach the cecum. The average time seems to be two hours. Complete emptying of the small intestine can be determined in only nine out of the twenty-seven cases. In these cases it averages about six hours, and varies from four to seven hours. The estimation of the time is rendered uncertain by a dilated, sacculated, or "residual" stomach, which constantly sends over splashes of bismuth into the small intestine until the organ has completely emptied itself.

Normally, the cecum is always situated well above the brim of the true pelvis. When the colon is ptosed, the cecum lies near the brim and in severe cases often hangs over into the true pelvic cavity. Dilatation of the colon appeared in eight cases, in which the colon had not been emptied in forty-eight hours.

In three of our cases, the vermiform appendix can be plainly seen, the lumen being patent and filled with bismuth. This occurred in one case after a cecum had become much engorged, and in another before the cecum had been filled. In these three cases, the situation and size could be proved. In one of the patients the bismuth

remained in the appendix four days after the cecum had been emptied.

In one of our patients, with a complete transposition of all the viscera and a coloptosis, a subacute appendicitis seemed probable. The radiograph demonstrated the cecum well below the line leading from the anterior superior spine to the umbilicus and on the left side, McBurney's point, where the place of tenderness existed, corresponded to the hepatic flexure. An operation has not been performed, as the pain and tenderness were probably caused by a localized colitis, as evidenced by the mucus in the stools. The bismuth radiogram proved the locality of the cecum, and, if it did not absolutely disprove the diagnosis of appendicitis, at least showed that the patient's appendix was on the left side and well down in the pelvic cavity. The patient improved under treatment, which was general, and local for the colitis, with an abdominal belt for support for the coloptosis.

Our results as to the position, size, shape, and motility of the colon have been very satisfactory. The organ can

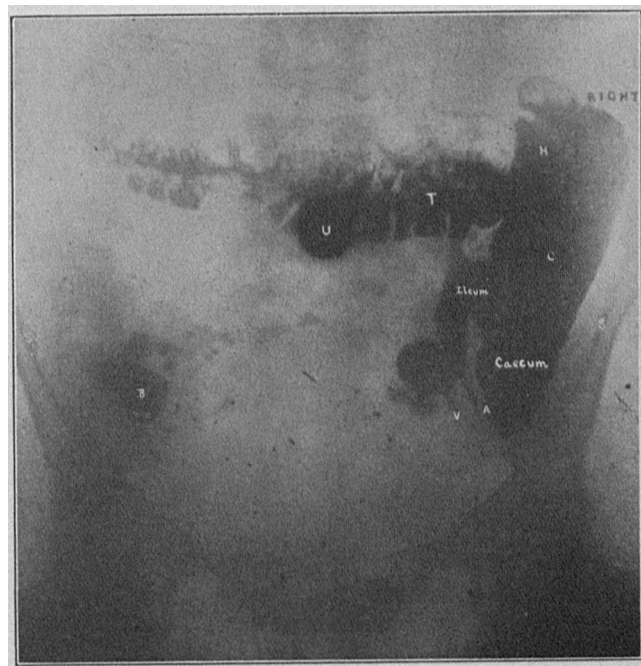


FIG. 2.—Radiograph taken five hours after the ingestion of a bismuth meal (Case 1). A, base; V, the tip of the vermiform appendix; U, umbilicus; T, transverse colon; H, hepatic flexure; B, remnants of bismuth in coils of small intestine; S. S., anterior superior spines.

be readily identified by its size, position, and sacculations. We have classified the cases into (1) normal colons, (2) abnormally long and looped colons, (3) ptosed colons, with or without abnormal length and loops, and (4) abnormally short colons. As to the shape of the colons, the following terms have suggested themselves to our minds: (a) straight, transverse colons, the strictly normal; (b) the U-shaped colon, caused by one large loop, dipping down toward the pelvis; (c) the V-shaped colon, which is similar; (d) the double U-shaped colon, with one loop from the hepatic and another from the splenic portion of the transverse colon; (e) the W-shaped colon, similar to the last; (f) the diamond-shaped colon, with the transverse portion running abruptly upward from the hepatic to the splenic flexure; and (g) the dragon-shaped colon. Our control radiographs show the constancy in the shape and posi-

tion of these colons, and in our estimation prove them to be peculiar to the individual. In some cases, hidden folds in the colon occur which give in later radiographs, after the colon is well filled, a much longer and looped appearance.

A ptosis of the colon is recognized by the low position of the caput coli and of the hepatic flexure. The hepatic flexure is normally at or above the level of the umbilicus. The loops of the colon may exist without a coexisting ptosis, as shown in some of our cases. The most constant point of fixation of the colon is at the splenic flexure where the intestine is attached by the phrenocolic ligament to the left abdominal wall under the spleen (Piersol). The average height of the splenic flexure, in our cases, is 4 inches above the umbilicus, a point which varies but little except in some extreme cases of coloptosis.

Motility of the colon varies, often out of proportion to its length. The motility in ptosed colons we think is always slow.

The sigmoid flexure has, as we expected, a variable length and size. In normal cases it is situated well

ventrally, so as to support the colon. Goldthwaite's posture¹⁵ taken immediately after eating, with the patient on his back, hips and thighs elevated, has been tried successfully in a number of cases.

CASE REPORTS

CASE 1.—M. McD., a woman aged 27, child's nurse, single, ever since childhood had been constipated and had to take cathartics or laxatives. For the past two years she had been getting worse, vomiting having occurred from one-quarter to one-half hour after meals. She had pain, which was most marked in the epigastrium, but which also at times extended lower down on the right side of the abdomen and into the right hip and leg. Distress and soreness after eating were invariably present over the sternum. During the summer and fall of 1910 she developed hemorrhoids, which became inflamed and were removed in January, 1911.

After the operation, the patient's symptoms continued; the obstinate constipation could not be relieved by medical means, the chief of which were olive oil internally, ordinary enemas, and olive oil per rectum, colon massage, and vibration. Analysis of the gastric contents showed traces of free hydrochloric acid. The stools were very dry, hard and contained undigested food.

In May, 1911, the bismuth-Röntgen-ray test was made. This showed a stomach of normal shape and size, but ptosed, with a complete emptying in three hours. The bismuth reached the cecum in two hours, and the small intestine was completely emptied in five and one-half hours. Four hours after the ingestion of the bismuth, the cecum and part of the transverse colon were filled, the transverse colon straight, and the hepatic flexure 2 inches above the umbilicus, and therefore no ptosis apparent. The shadow of the bismuth in the ascending colon was so heavy that in consideration of the next picture the colon seemed to be folded on itself (Fig. 2.) One hour later the bismuth meal had not made any progress, but the apparent churning motion and the weight of the residue had dragged down what must have been a folded colon, and distended the appendix. This organ could be plainly outlined by the bismuth in the lumen; it overhung the brim of the true pelvis, was long, and made a sharp bend near its middle. In the last plate of the series, taken 101 hours after the bismuth meal, the outline of the bismuth in the appendix could still be plainly seen. Four hours later, or nine hours after the ingestion of the bismuth, a most remarkable drop in the transverse colon occurred, making a large central loop reaching down into the true pelvis, and the hepatic flexure was one inch lower than in the previous picture (Fig. 3). Twenty-six hours after the bismuth had been taken, very little progress had been made, but the whole colon was distended with gas which collected in the upper parts and raised apparently the level of the hepatic flexure. The sigmoid flexure was outlined in places, and the colon retained the same shape as before. The eighth plate of this series, taken forty-eight hours after the bismuth meal, showed very little progress in the looped colon. The bismuth did not show in the descending colon, but filled fairly well the sigmoid flexure. Up to this time the patient had had no bowel movement; seventy-seven hours after the bismuth meal, the colon retained its same position, but the main mass of the bismuth was still in the sigmoid flexure and the rectum. The sigmoid was very tortuous and long. The appendix was in the same position as before, and the same size. At the one hundred and first hour, without a movement, the bismuth was massed in the sigmoid and rectum and the appendix was still full of bismuth. It was two days after this picture was taken before the bismuth appeared in the stool, making a total of six days for the bismuth to pass through the gastro-intestinal tract. The diagnosis made in her case was a very severe case of constipation which, from the history, was probably the causative factor of the ptosed colon. At the time of writing, a laparotomy, with appendectomy and colopexy, is being considered.

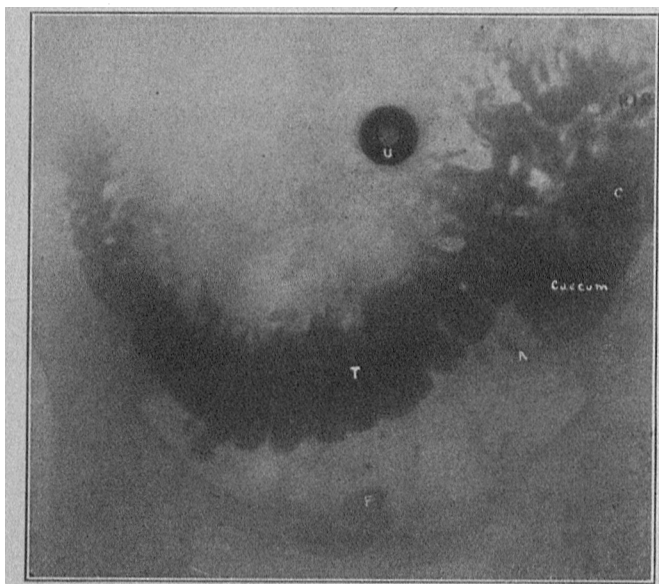


Fig. 3.—Radiograph taken twenty-six hours after the ingestion of a bismuth meal (Case 1). T, transverse colon, now become U-shaped; A, vermiform appendix, bent on itself; F, traces of bismuth in the sigmoid flexure; C, ascending colon. The lighter areas in the upper part of the colon are due to gas formation.

within the pelvic brim and does not pass much to the right of the median line. The length of abnormally long sigmoids may be estimated by the distance to the right of the median line and the height to which they extend. In three of our cases the shadows of the sigmoid and cecum impinge. In two of the cases long and dilated sigmoids are present, associated with colons of normal length. In one of our patients the sigmoid and rectum held the bismuth for over seventy-five hours and it was forty-eight hours more before the patient passed bismuth in the stool. This made a total residence of the feces in this part of the intestinal tract of over five days. The patient had a long-standing constipation, followed by hemorrhoids, which were excised. The radiographs show a long, looped and ptosed colon, with a long and tortuous sigmoid and upper portion of the rectum.

Our treatment for these cases of gastropnoxis, enteropnoxis and coloptosis consists of an abdominal wall support, often reinforced by two horsehair pads arranged

15. Goldthwaite, J. E.: Boston Med. and Surg. Jour., May 1910.

CASE 2.—B. S., a girl 18 years old, shirt-waist maker, said that her mother had an ulcer of the stomach. For years the patient had had obstinate constipation and three years before she had been operated on for appendicitis and abscess formation. Since that operation the constipation had been growing worse, with headache across the temple, cramplike pains in the abdomen, worse at night, vertigo, heartburn, nausea, and occasional attacks of syncope which compelled her to give up work. She had no appetite and would vomit small amounts of food after eating; she said that she had vomited a tablespoonful of bright blood two weeks before examination by us in February, 1911. Her diet had been reduced to a ridiculously low amount, with nothing before lunch time. She had lost weight, but was still fairly well nourished. Her chief complaints were obstinate constipation, frequent vomiting, and pain in the epigastrium and back. Examination of the abdomen showed a good-sized scar over the appendiceal region, abdominal musculature was of good tone, and there was no distention. The outlines of the stomach seemed normal, but there was tenderness over the whole abdomen in general, which was localized over the epigastrium and along the spine, and more marked at the level of the tenth and eleventh dorsal vertebrae. The Ewald test meal showed a 0.07 per cent. and 0.04 per cent. free hydrochloric acid on two occasions respectively, with a total acidity within normal bounds. No lactic acid was present.

The diagnosis of an ulcer of the stomach as being the cause of her trouble seemed unlikely, no blood or occult blood being found in the gastric contents or stools. Lavage relieved her somewhat, but only temporarily. February 27, the bismuth Röntgen-ray test was applied. The first picture, taken fifteen minutes after the swallowing of the bismuth, showed a nearly normal stomach, oblique fish-hook type, which emptied rapidly. The rugæ in the cardiac end were well marked. Within five hours the organ was completely empty. The small intestine was well down in the pelvic cavity.

The last picture in this series was taken twenty-four hours after the bismuth meal, and showed a ptosed cecum and splenic flexure. All the bismuth was in the large intestine, and the transverse portion of the colon has a long U-shaped loop, the lower border of which is 4 inches below the umbilicus, with its center 2 inches to the left of the median line. As this was one of our early cases, unfortunately we did not continue the series until the gastro-intestinal tract became completely empty. For a month and a half the patient was treated by regulation of the diet, massage and vibration, olive oil by mouth and per rectum, and by the usual instructions for regularity, etc., but an occasional cathartic was the only thing that gave her relief, and that only for a day or two. The flatulence, pain and vomiting continued. The pain now seemed localized over the left kidney with tenderness there, and an x-ray picture showed absence of renal or other calculi. An exploratory laparotomy showed the long, looped and ptosed colon, which was distended with feces, in spite of previous catharsis and high enemas. One adhesion of the cecum to the abdominal wall, as the result of the appendectomy, was cut. The cecum was dilated but otherwise not pathologic.

Palpation of the stomach gave no evidence of ulcer or growth. The kidneys, gall-bladder and other organs seemed normal. The loop of the transverse colon was freely movable and lay down in the pelvic cavity. With no permission to do a radical operation on the intestine, we closed the wound.

Since the operation the patient's condition has not improved, except for a short time after an abdominal web belt for the support of the ptosed colon was provided, and the patient sent to the country. At the end of last May she reported that the constipation was no better and that she still had attacks of sickness. She and her family have been advised of the probable necessity of a radical operation on the intestine, and of the dangers of the same, and have agreed to have it performed soon. We propose to sidetrack part of the colon, or possibly excise part of it.

CONCLUSIONS

1. The length of time that it takes the contents of the gastro-intestinal tract to reach each division of the tract, and the time in which the division is completely emptied,

can be definitely determined in each individual by the bismuth Röntgen-ray test.

2. The normal motility of each part of the gastro-intestinal tract can be definitely established.

3. The food immediately after ingestion begins to pass into the small intestine and by the end of an hour, at least one-quarter of the gastric contents is in the jejunum.

4. The stomach is emptied of 500 c.c. of milk or soup in two and one-half to four hours.

5. The existence of an increased amount of free hydrochloric acid in the gastric contents has no influence on the final emptying time of the stomach.

6. The time which this meal consumes in passing to the cecum averages two hours, varies from one to four hours, and is shorter in children.

7. The complete emptying time of the small intestine after this meal is probably about six hours.

8. Complete emptying of the colon consumes from twenty-four to forty-eight hours.



Fig. 4.—Radiograph taken three hours after the ingestion of a bismuth meal. This shows the rapid passage of food through the stomach and small intestine. The colon is dragon-shaped. H, hepatic flexure; T, transverse colon; D, splenic flexure; G, traces of bismuth in the stomach; B, bismuth in the small intestine. Case 6 [not reported in detail].

9. The bismuth-Röntgen-ray test is harmless and practical.

10. The ordinary methods of medical treatment can be more intelligently applied with the improvement in diagnosis accomplished by this test.

11. The bismuth-Röntgen-ray test should be employed before an operation is performed for a chronic condition of the gastro-intestinal tract.

We wish to thank Dr. George B. Wallace and Dr. John C. A. Gerster for their help in sending us patients, Dr. Arthur Mandel for his assistance in clinical and chemical analyses, and Dr. Alexander Smith, Dr. Egbert LeFevre and Dr. Harlow Brooks for their encouragement in undertaking the work.

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